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Techmarscincus jigurru, a small skink endemic to Mt Bartle Frere, Queensland
(Photo: G. Turner). See article on this species on page 2.



Initiation of male wrestling in *Nyctimystes dayi*. See article on this behaviour on page 11.

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NOTES ON THE HABITS OF THREE SKINKS FROM THE MT BARTLE FRERE SUMMIT, NORTH QUEENSLAND

Grant Turner
PO Box 2035, Innisfail, Qld 4860.

INTRODUCTION

The Wet Tropics region of north Queensland is recognised for its high degree of endemism among several groups of vertebrates, many species of which inhabit the regions isolated peaks that provide temperate 'island' refuges for these organisms (Nix & Switzer, 1991). Among these refuges is Queensland's highest mountain, Mt Bartle Frere where (at least) three skinks inhabit the montane forest and boulder-strewn heath above 1400 m. The Bartle Frere skink *Techmarscincus jigurru* was described in 1984 (as *Leiopisma jigurru*; Covacevich, 1984) from four specimens; *Eulamprus frerei* was described in 1992 from just two specimens (Greer, 1992). Both are endemic to the mountain's peaks and are regarded as 'rare' and 'insufficiently known' respectively (Covacevich & McDonald, 1993). The third species *Lampropholis robertsi*, which was described in 1990, is not confined to Mt Bartle Frere and inhabits montane forested peaks throughout the Wet Tropics region (Ingram, 1990).

There is limited information available on the biology of these species because of the restricted and isolated nature of their distributions and the recency of their discoveries. The observations below are intended to shed some light on the basic biology of these lizards.

METHODS

Over an eight year period (1998-2006) Mt Bartle Frere (17°45'S 145°49'E) was ascended from the eastern (coastal) side ($n = 18$) to the south peak (1622 m) and from the western (Atherton Tablelands) side ($n = 2$) to the northwest peak (1530 m). Except for one overnight trip, all visits were day trips and as such the time spent above 1400 m, where all

three species were encountered, was limited to a few hours typically in the late morning through to the early afternoon (maximum of four hours). Observations occurred in all months of the year except October. Visits tended to favour clear days when the summit was generally free from cloud although the rapidly changing weather conditions at high altitude (>1000 m) meant that a variety of conditions were experienced. Skinks were mostly observed close to or along the summit track. Interference was rare, but snout-to-length (SVL), tail length (both ± 0.5 mm) and mass measurements (± 0.05 g) were obtained from a small number of lizards. While adult size is not defined in the taxonomic descriptions of these species, the term 'adult' used below refers to individuals whose size was in the upper half of the stated SVL range in the descriptions; otherwise they are called 'juveniles'. The term 'neonate' is used to refer to presumed newborn lizards, identified by their relatively small size and conspicuous umbilical scar. Weather conditions were noted and temperatures were recorded in shade on the boulder field to the nearest 1°C.

OBSERVATIONS

Habitat description

The habitat on the elevated slopes and peaks of Mt Bartle Frere is a mosaic of two types: (i) heath that is strewn with boulders (referred to as the boulder field) and (ii) low (<15 m) dense rainforest. The boulders comprise granite that has a dark crust of lichens and algae. It occurs mostly as outcrops, some of which form jumbled cavernous piles. The rainforest is classified as simple microphyll vine-fern thicket (Type 10; Tracey, 1982: 36-38). The climate is cool (annual mean temperature 17°C) and very wet (>6000 mm annually) with the high peaks and slopes

windswept and enveloped in cloud for much of the year (Tracey, 1982; Trot, 1996: 20-21). All three skink species were found in both habitat types.

Activity

In four out of the 20 visits to the summit no skinks were seen. Three of these visits occurred in winter (June and July) and another in September; in all instances the temperature was below 16°C. Low numbers of skinks ($n < 5$) occurred on cool days ($< 16^\circ\text{C}$) and also on clear days in December and January when temperatures in direct sun on the boulder field exceeded 50°C. Most skinks were seen active when shade temperatures were in the range 20-25°C. There was a positive correlation between temperature and the number of *T. jigurru* sighted (Spearman $r = 0.51$, $p = 0.031$, $n = 18$). On one visit in February, few lizards were initially seen because of hot conditions, but this situation changed after the mountain was drenched by a thunderstorm. As the storm cleared, large numbers of *T. jigurru* emerged onto the steaming boulders. A few *T. jigurru* were active in quite cool conditions and in one instance a juvenile was active on the ground in cold, wet and blustery conditions (16°C). Activity in *T. jigurru* occurred at any time of the day while at night they retreated into cracks and gaps in rock outcrops (Covacevich & McDonald, 1991: 71; pers. obs.).

Comparative abundance

Techmarscincus jigurru was encountered on all occasions that skinks were seen ($n = 16$). It was the most abundant of the three skinks and was also encountered in the largest numbers (maximum ≈ 40). *Lampropholis robertsi* was the next most abundant being seen on 50% (8 of 16) of visits and was reasonably common (maximum 15), while *E. frerei* was encountered on 31% (5 of 16) of visits and was also reasonably common (maximum 12).

Habitat use

All three species were regularly seen on exposed rocks and boulders. On hot days

($> 50^\circ\text{C}$ in direct sun in summer), all three species were seen in dappled sun on rocks and logs in rainforest; a few *T. jigurru* were sighted down crevices and on cool, shaded boulders on the boulder field. Both *T. jigurru* and *E. frerei* were observed protruding from hollowed-out branches (both $n = 4$). By contrast *L. robertsi* was encountered on stones and low flat boulders or on the ground ($n > 20$). Neonate and juvenile *T. jigurru* were encountered on the ground as well as on rocks. Only two adult *T. jigurru* were observed on the ground and these were basking in sunlit patches on the forest floor. No *E. frerei* were observed on the ground but were common on boulders. Both juvenile and adult *L. robertsi* were observed on the ground in both the boulder field and rainforest. Shelter sites for *T. jigurru* included exfoliating slabs, crevices and gaps in between abutting boulders (Ehmann, 1992: 262; pers. obs.). Shelter sites for *E. frerei* included crevices and hollowed branches while those for *L. robertsi* are not known.

Basking

Techmarscincus jigurru and *E. frerei* often basked near rock crevices and overhangs where they retreated when disturbed (Anthony, 1995, 1999; pers. obs.). When cold SE winds buffeted the boulder field, but conditions were warm enough for basking, these species would lie still and absorb warmth from rocks that were protected from the wind. Several *T. jigurru* assumed a basking posture wherein the forelimbs, and sometimes the hindlimbs, were folded back against the flanks, giving a streamlined appearance. Specimens of *L. robertsi* would often bask with their tails curled around near their heads. On cool sunny days all three species were typically quite approachable, being more concerned with basking than retreating, and one could approach within a metre of many lizards before they retreated.

Behaviour

While *T. jigurru* were generally solitary, several were seen on the same rock within 0.2 m of

each other; chasing was seen on two occasions over a distance of approximately one metre and seemed to result from one individual encroaching on the other's 'territory'. Both adults and juveniles of *T. jigurru* and *E. frerei* had a tendency to return to the same position after being disturbed when basking. For example, one *T. jigurru* had its head protruding from a hollow tree branch with two exits (approximately 15 cm apart) and when disturbed the lizard repeatedly moved from one exit to the next and recommenced basking. In other instances lizards would retreat down crevices on being disturbed only to reappear at the same spot minutes later. *Lampropholis robertsi* typically occurred singly, except sometimes when basking they were seen in small sunlit-patches on the forest floor in groups of up to six individuals, mostly adults. None were in direct body contact but were only centimetres apart.

Diet

A few lizard faecal pellets located on boulders contained insect matter, with dipterans clearly identifiable though the lizard species was not known. While several *T. jigurru* were observed from a distance consuming or pursuing prey, these items could not be identified except in one instance when *T. jigurru* (SVL \approx 40 mm) was observed to capture and consume a small dipteran. Ehmann (1992: 262) records *T. jigurru* as hunting insects and spiders.

Reproduction

Gravid *T. jigurru* were encountered in November ($n = 1$) and December ($n = 2$) and neonates in January ($n = 2$) and February ($n = 3$). Gravid female *E. frerei* were seen in December ($n = 4$) and a neonate in January. Gravid *L. robertsi* were observed in December ($n = 3$) and February ($n = 1$) and juveniles in May (no neonates were seen).

Appearance

Juvenile *T. jigurru* possess dorsal and ventral colouration that is very similar to adults except juveniles have regular pale blue-grey stippling on the tail. Juvenile *E. frerei* are also

very similar in appearance to adults although the lemon yellow ventral flush of adults is lacking. Most *T. jigurru* with SVL > 40 mm had regenerated tails (65%; 22 of 34) and a few even had compound regenerated portions. Some adult *T. jigurru* were observed to have small clusters of red mites around the axillae ($n = 5$).

DISCUSSION

The skinks living on the Mt Bartle Frere summit are subjected to a highly changeable weather conditions and even the summer months are regularly punctuated by inclement weather. Much of the skinks' activity patterns and behaviour reflect these conditions. It appears that the skinks are inactive for several months during the winter (June-July) but otherwise take full advantage of basking opportunities. The relatively low numbers of lizards recorded during some visits in the summer months (January/February) can be attributed to excessively hot conditions on the boulder field. On such days lizards tended to occupy the rainforest and boulder piles where there was shade.

There appears to be fairly broad overlap in habitat utilisation between *T. jigurru* and *E. frerei*. While the holotype of *E. frerei* was collected from a crevice in a dead tree (see also Anthony, 1995), the observations above indicate that the species also occurs commonly on boulders. The saxicoline *T. jigurru*, while typically observed on boulders, was also observed on logs, branches and on the ground. Several morphological features possessed by *T. jigurru* are typical of saxicoline skinks (Covacevich, 1984) and are consistent with its preference for the boulder field habitat. *L. robertsi* by contrast tends to be mainly terrestrial in habit, typical of the genus (Wilson, 2005: 131). All three species appear to move between the boulder field and adjacent forest depending on weather conditions, though appear more common on the boulder field.

The approximate timing of oviposition/parturition can be deduced in the three species.

Shea (1987) recorded a gravid female *T. jigurru* collected in early November containing four shelled eggs, which is consistent with the occurrence of gravid females above. The occurrence of neonates indicates that *T. jigurru* eggs hatch from February through to April. Nothing was known about reproduction in *E. frerei* (Greer, 1992), however the occurrence of gravid females in December and a neonate in January suggests that parturition occurs in mid-summer. In *L. robertsi* oviposition probably occurs in mid to late summer and hatching in early to mid-autumn. The timing of reproduction in the three species appears to be quite similar to skinks inhabiting southern temperate regions of Australia rather than those of the surrounding tropical lowlands (pers.obs.). A detailed comparison of the timing of reproductive events in the skinks inhabiting the Bartle Frere summit with allied species inhabiting lower altitudes (e.g. *Eulamprus tigrinus* and *Lampropholis coggeri*) would be of interest.

Adult *T. jigurru* can attain sizes considerably larger than those indicated in the type description, which was based on a small sample size (SVL 34.5-67.2 mm, $n = 4$; Covacevich, 1984). The SVL of 91 mm recorded for one individual is probably close to the upper limit for the species though specimens estimated to be in the 75-85 mm SVL range were regularly seen. Only one SVL of 66 mm is quoted in the original description of *E. frerei* (Greer, 1992) and most specimens observed were around this size. In *L. robertsi* the neonate SVL of 19 mm (Table 1) falls just outside the stated range of SVLs for the species (21-49 mm, $n = 37$; Ingram, 1990).

The Marsh Snake *Hemiaspis signata* was the only snake species recorded from the boulder field habitat. Two adults were encountered: one was observed basking on a flat-topped boulder on which *T. jigurru* had been observed basking on previous visits; the other was observed active on the ground in a patch of rainforest near the summit on a sunny day in February when skinks were active. The occurrence of *H. signata* on the boulder field

and forest patches within the boulder field is not surprising as the species commonly occurs at high altitude in the Wet Tropics (M. Anthony, pers. comm.) and does occur at lower altitudes in the region (pers. obs.). This species feeds primarily on skinks and frogs (Shine, 1987) and thus is likely to be a predator of the skinks on the Mt Bartle Frere summit.

Finally, the basking posture of *T. jigurru* wherein the limbs were pressed against the body has been noted in other skink species (e.g. *Eulamprus tympanum*, see Figure 31.10 in Hutchinson (1993) and *Pseudemoia pagenstecheri*, pers. obs.) and thus may be quite widespread among skink genera. Whether the posture is adopted to maximise the exposure of limbs to the sun, improve blood flow to the limbs, for comfort or for some other reason is not known.

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Table 1. Size of *Techmarscincus jigurru* (n = 6) and *Lampropholis robertsi* (n = 3). Asterisks indicate a regenerated tail. Abbreviations: SVL = snout-to-vent length, TL = tail length, NR = not recorded.

Species	SVL (mm)	TL (mm)	Mass (g)
<i>T. jigurru</i>	28	45	0.5
	66	95*	4.5
	67	112*	5.2
	81	105*	8.0
	82	112*	7.8
	91	121*	NR
<i>L. robertsi</i>	19	24	NR
	42	57	1.5
	43	58	1.7

Figure 1. Boulder field below the summit of Mt Bartle Frere, habitat of *Techmarscincus jigurru*, *Eulamprus frerei* and *Lampropholis robertsi*.



Figure 2. A gravid female *Eulamprus frerei* basking on a boulder ledge.



PLANT CONSUMPTION IN AUSTRALIAN GECKOS: SAP FEEDING BY THE OCELLATED VELVET GECKO *OEDURA MONILIS*

Jodi J.L. Rowley*, Robert Puschendorf and Scott Cashins

School of Marine and Tropical Biology, James Cook University, Townsville, Qld 4811.

*Email: Jodi.Rowley@gmail.com.

INTRODUCTION

Most lizards are predators of small animals, and plant consumption in lizards had long been considered atypical and restricted to a small proportion of species (Cooper & Vitt, 2002). While completely herbivorous species make up around 3% of the total lizard fauna (Iverson, 1982), it is becoming increasingly apparent that many lizards do eat plant material, be it only occasionally or in small quantities (Cooper & Vitt, 2002). For lizards in which plants form only a small part of the diet, easily digestible products such as nectar, pollen, or sap are favoured (Cooper & Vitt, 2002). These products are likely to be valuable food resources due to their high concentration of sugars and nutrients (Greer, 1989).

The consumption of a plant material is particularly infrequent in geckos (Cooper & Vitt, 2002), with exceptions from New Zealand (Whitaker, 1987), New Caledonia (Bauer & Sadlier, 1994) and islands in the Indian Ocean (Nyhagen *et al.*, 2001; Staub, 1988). While the majority of Australian geckos are opportunistic arthropod feeders (Greer, 1989), a number have been observed eating plant sap, particularly species within the predominantly arboreal genera *Gehyra* and *Strophurus*. To date, sap feeding in Australian geckos has been reported for *Christinus guentheri* (Cogger *et al.*, 1983), *Christinus marmoratus* (Dell, 1985), *Gehyra australis* (Letnic & Madden, 1997), *Gehyra cf. baliola* (Couper *et al.*, 1995), *Gehyra dubia* (Couper *et al.*, 1995), *Gehyra purpurascens* (Gaikhorst & Lambert, 2005), *Gehyra variegata* (Dell, 1985), *Rhacodactylus australis* (Couper *et al.*, 1995), *Strophurus assimilis* (Gaikhorst & Lambert, 2005), *Strophurus spinigerus* (Couper *et al.*, 1995), and *Oedura*

reticulata (Dell, 1985). Here we report a further Australian gecko species feeding on tree sap, the Ocellated Velvet Gecko (*Oedura monilis*).

OBSERVATION

On 25 May 2006, at the James Cook University Kirrama Field Station (18°11'30"S 145°44'25"E, 589 m asl), we observed a single *O. monilis* on a lime tree (*Tilia* sp.). The lime tree was planted in the vicinity of the field station building and was surrounded by open, eucalypt forest. At 2030 hr, the *O. monilis* was observed at approximately 1.6 m in height on the trunk of the tree, licking a small (approximately 4 cm²) patch of sap (Figure 1). There were no insects near the sap patch, and the sap was derived from the tree rather than from insect exudates (ie. honeydew; Markus *et al.*, 2001). We observed the individual for two hours, and although we were in very close proximity and took numerous photographs, it did not stop feeding on the sap during this time. Its tongue movements were slow and deliberate. We moved away from the animal at approximately 2245 hr, and when we returned at 2300 hr, the gecko could no longer be located.

DISCUSSION

This observation of *O. monilis* is the first report of an Australian gecko utilizing food resources from an introduced tree. All other reports of Australian geckos feeding on plant sap have been on native plants including *Acacia* (Dell, 1985; Couper *et al.*, 1995), *Grevillea* (Gaikhorst & Lambert, 2006) and *Eucalyptus* (Shea *et al.*, 1988).

It is perhaps not surprising that *O. monilis* has

never been observed feeding on tree sap, given the likely highly opportunistic nature of the act. Other species of gecko have been found to feed on non-traditional, energy-rich food resources when presented the opportunity. For example, the Palauan gecko *Gehyra brevipalmata* has been observed licking not only tree sap, but also, open soft drink containers (Crombie & Pregill, 1999), and a number of Australian geckos have been reported feeding on sugar-based substances in captivity (Greer, 1989).

Utilisation of plant resources such as sap may be an occasional event for the majority of lizard species, and as a result has gone largely undetected. Further incidental observations such as the present study are likely to reveal that plant consumption in lizards is much more widespread than previously understood. This may be the case particularly in opportunistic, active foragers such as *O. monilis*, which may be more likely to encounter plant food as they search a wide area for prey, closely inspect certain plants, and use their chemical sensors to identify and locate animal prey (Cooper & Vitt, 2002). It is likely that further observations will reveal that the majority of active-foraging geckos in Australia and elsewhere opportunistically feed on 'free', high-energy plant resources when accidentally located, and may even use chemoreception to seek them out, particularly at times of low insect abundance.

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Figure 1. *Oedura monilis* feeding on tree sap



OBSERVATIONS OF PHYSICAL INTERACTIONS BETWEEN CONSPECIFIC MALE RAIN FOREST STREAM FROGS *LITORIA GENIMACULATA* AND *NYCTIMYSTES DAYI* (ANURA: HYLIDAE).

Jodi J. L. Rowley

School of Marine and Tropical Biology, James Cook University,
Townsville, Qld 4811.

Email: Jodi.Rowley@gmail.com.

INTRODUCTION

A male frog's reproductive success may depend on his ability to attract female conspecifics to his calling site and defend it from other males (Given, 1988; Wells, 1977a). Neighboring males may therefore compete strongly with each other for approaching females, especially when females are uncommon at breeding sites. This competition may result in physical encounters, with males wrestling with each other for calling and/or breeding sites known to significantly improve the chances of attracting a mate (Katsikaros & Shine, 1997; Kluge, 1981; Magnusson *et al.*, 1999; Pengilley, 1971; Robertson, 1986; Wells, 1977a). Alternatively, males may not defend specific sites, but attempt to maintain a fixed distance between themselves and other males (Wells, 1977b), perhaps to reduce acoustic interference.

Physical interactions between male frogs, such as wrestling, have been reported in a number of Australian frogs, almost all within the family Myobatrachidae (e.g. Bulbert *et al.*, 2006; Bush, 1984; Katsikaros & Shine, 1997; Pengilley, 1971; Robertson, 1986). In Australia, wrestling has only been reported between individuals of a single species in the family Hylidae, *Litoria genimaculata* (Richards & James, 1992). However, this previous report was based on a single pair of males and wrestling bouts were not described. Here I report observations of physical interactions between conspecific males of two rain forest stream frogs, *Litoria genimaculata* and *Nyctimystes dayi*. This is the first report of male-male interactions in *N. dayi* and the only description of such interactions in *L. genimaculata*.

METHODS

During the course of tracking rain forest stream frogs in northern Queensland, Australia, I observed a number of interactions between conspecific males of *Litoria genimaculata* and *Nyctimystes dayi*. All observations took place at night (1900-0400 hr) between March 2004 and October 2005. In all instances, I observed the frogs from a distance of 1-3 m, using a normal torch-light. Both *L. genimaculata* and *N. dayi* are highly sexually dimorphic, and males can easily be identified. On most instances, the events leading up to the observed interactions and their outcomes were not observed, as I was conducting other research at the site and only opportunistically observing and recording details of male-male interactions. In all cases, no other frogs were observed within 3 m of the interacting males.

OBSERVATIONS

Litoria genimaculata

Male *L. genimaculata* were observed in contact nine times. In all but one occasion, these interactions were observed only briefly (<5 mins), and did not involve any of my study animals (i.e. individuals being tracked). All male-male contact observed took place on terrestrial vegetation adjacent to the stream or on dry boulders within the stream. During six of these observations, males were found sitting motionless, with one male on top of the other. It is unlikely that any of these interactions were misguided attempts at mating, as they were never observed in typical amplexus postures, with frogs often not facing the same direction. Foot-flagging, as described by

Richards and James (1992), was observed on only one occasion, with the upper male slowly and repeatedly extending his hind legs behind him, one leg at a time.

Only one observation of male-male interaction involved any of my study animals. On this occasion, two individuals, which were previously located 5-20 m apart, were observed in physical contact with each other in terrestrial vegetation directly adjacent to the stream (Figure 1). Both individuals were motionless throughout my observations (15 minutes), and were still in the same position approximately three hours later. The next day, the larger male remained at the same site, but the smaller male had returned to its previous location 4 m away. These individuals were not observed in contact again.

On three occasions, males were observed wrestling with each other, facing each other with arms interlocked and frogs 'rolling' around the site. The events leading up the observed wrestling bouts were not observed, and their outcome was unclear, with both males rapidly separating and the potential 'winner' of the bout not readily apparent.

Detailed measurements of both frogs were made in three instances (Table 1). In each of these cases the larger male, in terms of both snout-vent length and weight, was on top during physical interactions.

Nyctimystes dayi

Nyctimystes dayi males were observed in contact four times during the surveys. During two of these observations, males were sitting motionless on terrestrial vegetation along the stream, with one male sitting on the other, in a very similar manner to *L. genimaculata*. However, during the other two observations, males were engaged in wrestling bouts. These interactions, which both took place on emergent rocks in the stream, began with one male moving on top of the other (Figure 2), and resulted in both individuals facing each other, interlocking forelimbs, and wrestling for a few seconds before rolling off the rock and into the stream. The outcome of these

interactions was not observed as frogs were rapidly carried downstream.

DISCUSSION

During this study, male *L. genimaculata* and *N. dayi* were observed engaging in physical interactions. While some of these interactions appear to be relatively passive, frogs of both species do escalate such interactions into wrestling bouts. As male *L. genimaculata* and *N. dayi* outnumber females at the stream (Richards & Alford, 2005; Rowley & Alford, unpublished data), competition for females may be high. Indeed, I did not observe any male-male interactions in the sympatric frog species, *Litoria nannotis*, outside of passive, mixed-sex aggregations at retreat sites. In *L. nannotis*, females tend to stay within the stream, often located in mixed-sex aggregations, which may serve to reduce competition between males for females (Hodgkinson & Hero, 2001; Rowley & Alford, in press).

Male *L. genimaculata* and *N. dayi* may be competing for specific sites such as calling sites, or may simply be attempting to maintain inter-male spacing (e.g. Robertson, 1986). However, as males of both species were often observed using the same calling site on different nights (Rowley & Alford, unpublished data), some calling sites may result in a higher reproductive success and be worth defending.

The form and intensity of aggressive behaviour involving physical contact is variable (Wells, 1977b). However, in general, male frogs that engage in wrestling bouts will interlock forelimbs with the intention of flipping or repelling their opponent (Wells, 1977b), as observed in both *L. genimaculata* and *N. dayi*. However, due to the potentially high costs of combat, in terms of energy expenditure, time diverted from other activities, and potential injury, animals should attempt to assess asymmetries in ability before engaging in combat (Enquist & Leimar, 1983; Maynard Smith, 1982). This may be why so many physical encounters observed between males were passive, with males of both species perhaps

able to assess their abilities before escalating to physical combat. However, it is possible that wrestling bouts did eventuate between these pairs when I was no longer observing them.

An important predictor of fighting ability is body size (Andersson, 1994), with larger body size typically conveying advantages in physical contests (Howard, 1978; Robertson, 1986; Wells, 1977a; Wells, 1979). During this study, on instances where I was able to record details for both members of a pair of *L. genimaculata*, the upper male was always larger. In addition, on the only occasion where outcome was observed, the larger male remained at the site of contact, and the smaller male moved away. It remains unclear as to whether pattern is representative of *L. genimaculata* as a whole due to the small sample size in this study. Further, other factors such as residency (Fellers, 1979) and age (Howard, 1978) have also been shown to influence the outcome of aggressive interactions in frogs.

The use of specialized vocalizations, or warning calls, prior to aggressive encounters is common (Gerhardt & Schwartz, 1995), but was not observed in either *L. genimaculata* or *N. dayi*. As the breeding calls of these species are not particularly loud with respect to the stream, we may have simply not detected any such calls. Alternatively, these species may not vocalize prior to physical encounters, instead evolving visual threat displays such as the foot flagging observed in Richards and James (1992) and in the present study.

Male competition resulting in physical encounters and wrestling between male frogs may be more taxonomically widespread than currently documented. It may simply be that in many frog species, physical encounters are rare or difficult to detect, with only thirteen observations of physical interactions and wrestling observed in over five months of surveys (5-12 hours a day) during this study.

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Table 1. Details of male *L. genimaculata* observed in physical interactions.

Date	Time	Site	SVL (mm)	Weight (g)
24.iii.2004	2230	Frenchman Creek, Babinda (17°20'S 145°55'E)	Upper: 42.3 Lower: 41.5	Upper: 5.5 Lower: 4.5
31.vii.2004	2055	Python Creek, Tully Gorge (17°46'S 145°35'E)	Upper: 43.9 Lower: 40.3	Upper: 6.7 Lower: 5.5
17.iii.2005	2215	Frenchman Creek, Babinda (17°20'S 145°55'E)	Upper: 40.7 Lower: 35.3	Upper: 4.95 Lower: 3.65

Figure 1. Male *L. genimaculata* at Tully Gorge, 2055 hr, 31 July 2004.

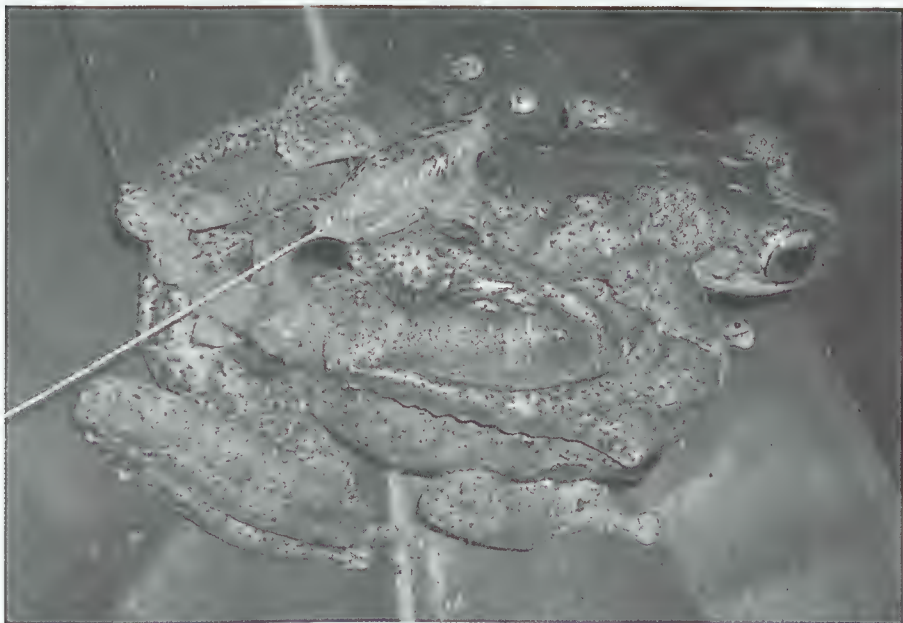


Figure 2. Male *Nyctimystes dayi* at Tully Gorge, 2135 hr, 26 February 2005.



FOSSORIAL FROG FORAGING BY THE WESTERN TIGER SNAKE, *NOTECHIS SCUTATUS* (ELAPIDAE)

Paul Orange

18 Balfern Court, Hamersley, WA 6022.

The diet of the western tiger snake, *Notechis scutatus* (also known as *Notechis scutatus occidentalis* and *Notechis ater occidentalis*), is well documented and consists of frogs, lizards, birds and mammals, with frogs predominating in mainland populations (Shine, 1987; Bush *et al.*, 1995; Storr *et al.*, 2002; Aubret, 2004; Aubret *et al.*, 2004, 2006). However, whilst dietary preferences are well recorded, methods of obtaining prey are less so. Elapid snakes are generally viewed as being active foragers (Mushinsky, 1987; Greer, 1997), and tiger snakes appear to conform to this (Shine, 1977, 1987; Fearn, 1993; Bush, 1994; Aubret *et al.*, 2005). To date, my own observations with western tiger snakes support this.

I have regularly observed western tiger snakes at Herdsman Lake (31°55'44"S 115°48'19"E), a nature reserve situated within the Perth metropolitan area, Western Australia. Herdsman Lake is a perennial lake, well known for its population of tiger snakes (Department of Conservation and Land Management *et al.*, 2001; Aubret, 2004; Aubret *et al.*, 2004, 2005, 2006; Orange, 2005). Most tiger snakes encountered at Herdsman Lake are observed basking or disappearing into dense grass (presumably having sensed my approach). However, some individuals have been approached whilst foraging and were apparently unaware of my presence.

Tiger snakes at Herdsman Lake feed mainly on frogs (Aubret, 2004; Aubret *et al.*, 2004, 2005, 2006). Six frog species are known from the site: *Crinia glauerti*, *C. insignifera*, *Heleioporus eyrei*, *Limnodynastes dorsalis*, *Litoria adelaidensis* and *L. moorei* (Dept of Conservation and Land Management *et al.*, 2001). Of these, Aubret *et al.* (2004) recorded *Crinia insignifera*, *Litoria adelaidensis* and *L. moorei* as prey items of tiger snakes at

Herdsman Lake. Although *Litoria* are colloquially known as tree frogs, both local *Litoria* species may be encountered on the ground and in water (Main, 1965; Bush *et al.*, 1995; pers. obs.), where they presumably fall prey to tiger snakes. Shine (1987) recorded *Litoria moorei* from the stomachs of Western Australian tiger snakes and noted that all of the frogs identified to species level were "terrestrial rather than arboreal forms" (p. 237). However, as tiger snakes have been observed climbing amongst the bulrushes, *Typha orientalis*, at Herdsman Lake (S. Nevill, pers. comm.), also habitat for *Litoria* species (Bush *et al.*, 1995; pers. obs.), perhaps not all frogs are taken terrestrially. Moreover, western tiger snakes have been recorded ascending low vegetation in search of nestling birds (Bush *et al.*, 1995), so it seems feasible that an opportunistic forager would also take frogs so encountered. To date, however, my observations agree with Shine (1987), and predation events witnessed by me have involved tiger snakes preying upon terrestrial frogs (Myobatrachidae).

OBSERVATIONS

On 2 October 2006, at about 10.15 am, I encountered a tiger snake situated approximately three metres from a well-used track (pedestrians and cyclists) in an area of flooded gum (*Eucalyptus rudis*) with a sparse understorey of shrubs. The weather was sunny and pleasantly warm, the temperature in the low twenties (Celsius). The snake lay motionless in a somewhat exposed situation, close to the busy track, and appeared to be missing its head. This effect was heightened by its oddly contorted position, as if it had been decapitated and died writhing (having previously seen a dead tiger snake adjacent to a track at Herdsman, I wasn't altogether

surprised by the sight). On moving closer I became aware of a certain 'tenseness' about the snake, and realised that its head was buried in the sandy soil. I suspected that the snake may have located a frog in a shallow burrow, but whether the burrow had been open or the snake had pushed its head into the soil to locate the frog I could not determine; the loose, 'soft' soil had collapsed around the snake's neck. From what could be seen, I estimated that about 8 cm of the head and neck were submerged in the soil. A similar hole was located several centimetres away, which I assumed was made by the snake previously.

The snake was watched for some time, and several flashlight photographs were taken (Figures 1-2). Despite this, the snake did not move from its position. The snake was left unattended for a short period, and upon my returning about five minutes later it had emerged from the hole; its head, still with soil adhering, was raised off the ground and the posterior half of a frog was protruding from its mouth. While the snake was being observed from a distance of about 3 m, the frog kicked a little, briefly. The short legs of the frog and its fossorial habit indicated that it was a myobatrachid frog.

After swallowing the frog the tiger snake moved off into the bush. Its total length was about 70 cm and some of its tail was missing (a condition typical for a Herdsman Lake tiger snake; Aubret *et al.*, 2005; pers. obs.). The hole vacated by the snake was shallow, about 5 cm deep (but may have collapsed as the tiger snake removed its head) and the soil was quite damp, more so than I had expected at so shallow a depth. The total time recorded for this incident, from first encounter to snake moving off, was approximately twenty minutes.

On 5 November 2006 I was at Herdsman Lake from about 10.15 am until 11.45 am. The temperature range for the Perth metropolitan area that day was 17-31°C (according to that evening's news), although during our time at the lake it did not seem to have

reached the daily maximum. It wasn't until after about 11.00 am, when the temperature appeared to drop a little and some storm activity commenced (thunder and a little spotting of rain), that tiger snakes were observed. Four tiger snakes were seen in the next forty-five minutes. The first was only seen briefly disappearing into dense green grass near a drain, but the following three were all observed actively foraging.

The first foraging snake was in a fairly open area of shrubs, with little groundcover other than a shallow covering of leaf litter (an area undergoing revegetation; Dept. of Conservation and Land Management *et al.*, 2001). It was first noticed with its head under the leaf litter/uppermost layer of humus, similar to the October observation. Suddenly a frog (*Limnodynastes dorsalis*) erupted from the leaf litter ahead of the snake and moved rapidly towards us. The snake poked its head out of the leaf litter as if to give chase, but our presence disturbed it and the snake made off in the opposite direction.

The next snake was noticed in the immediate vicinity, about 25 metres away. It too was engaged in pushing its head into the leaf litter/topsoil, and we were able to approach closely and observe it for about ten minutes (Figure 3). It forced its head into the substrate so vigorously that, at times, the effort could be seen in its forebody, which would flex and arch somewhat, trembling slightly with the exertion. At one point the snake became comparatively still and it appeared as though its neck became briefly distended, as if perhaps it were swallowing a small frog underground. After this the snake continued its fossorial activity, gradually coming towards the surface. During this time the majority of the snake's body had been exposed on the surface, in the open with no ground cover. Eventually the snake's head broke through to the surface, covered in humus and soil, tongue flickering, as if it were attempting to re-orient itself to the sudden change in its situation. At this point I was about one metre from it and hence able to observe it very

clearly. As the soil began to fall from its head one of its eyes could be seen, and a slight movement by me caused it to emerge suddenly, flattening its forebody. It weaved around for a while, neck flattened, until suddenly disappearing into a concrete drain running beneath a nearby track.

The final snake was noticed almost immediately afterwards, in a wooded area (*E. rudis*) with considerable ground cover of grasses and leaf litter. It was sprawled out and appeared to have just finished foraging in a similar manner, there being two indentations in the leaf litter/humus alongside it. Our approach disturbed it and it retreated into nearby grass.

DISCUSSION

It is unusual to have observed three tiger snakes foraging in a similar manner in such a short period. Weather conditions were probably a contributing factor, the day being overcast and humid with some storm activity. The previous day and night had been conducive to frog (and hence, tiger snake) activity: cloudy, with occasional showers, quite heavy at times. These conditions may have encouraged frogs in burrows to move closer to the surface, or frogs active the previous night to not burrow so deeply during the day. Either way, frogs were probably closer to the surface and the tiger snakes were taking advantage of the situation. The observation of a tiger snake foraging in this manner the previous month indicates that perhaps this behaviour is not unusual amongst the tiger snakes at Herdsman Lake.

How widespread fossorial frog foraging by tiger snakes remains to be seen. For such a foraging technique to be successful certain environmental conditions would appear to be necessary: sufficient rainfall/moisture to 'encourage' superficial burrowing by myobatrachid frogs, and a soil structure conducive to fossorial foraging by tiger snakes. Frogs burrowed deep and/or in heavier soil would be unlikely to be predated in this manner. Frogs in deep burrows may also be less likely

to be detected by tiger snakes in the first place; chemoreception (the most likely method by which tiger snakes locate such prey) is probably less effective with deeply buried prey.

It is worth considering whether the perennial nature of Herdsman Lake and the correspondingly high water-table might have an effect upon the frogs' burrowing habits (and hence, fossorial foraging by tiger snakes). *Heleioporus eyrei*, which occurs at Herdsman Lake, "burrows in sand to moist sub-soil" (Main, 1965: 53), and calling activity in this species has been recorded independent of rainfall, at locations "where a shallow water-table kept the surface soil moist" (Lee, 1967: 407). Would the availability of permanent water/moisture at Herdsman Lake induce frogs to burrow superficially most (all?) of the time and thus render them vulnerable to tiger snakes year round? To ascertain this I revisited Herdsman Lake in February 2007 to check soil conditions, specifically in those areas where I had witnessed fossorial foraging by tiger snakes. I excavated a number of holes, using my fingers to gain at least some impression of the task facing a burrowing tiger snake. In all instances the soil was dry and friable near the surface, becoming compacted, but still dry, after a few centimetres. From this I concluded that the frogs would certainly burrow deeper than I had (ca 12 cm) in order to reach moist sub-soil and avoid desiccation (Main, 1965, gives an aestivation burrow depth of 10-30 cm for *Heleioporus eyrei*). Tiger snakes would probably be unable to penetrate deeply into the compacted soil. It would seem that wet weather conditions are necessary to bring the frogs to/near the surface and to 'soften' the soil for the tiger snakes to forage and feed in this manner.

The term "active forager", whilst a good description of a tiger snake's prey-seeking behaviour, is a general term and encompasses a range of more specific behaviours. For instance, Mirtschin and Bailey (1990) reported Krefft's tiger snake (*Notechis ater ater*) nuzzling beneath submerged rocks in search

of tadpoles, and Fearn (1993) records Tasmanian tiger snakes (*N. scutatus*) habitually raiding bird nests, ascending trees, shrubs, outbuildings and into the roofs of houses in search of them. My observations of fossorial foraging by tiger snakes for a specific prey item (myobatrachid frogs) under specific conditions are a further example of the ability of tiger snakes to respond to a certain situation and food source. These observations may also add support to Aubret's (2004: 365) suggestion of "habitat-dependent behavioural plasticity" in tiger snakes.

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Figure 1. Fossorial frog foraging by the western tiger snake, *Notechis scutatus*, at Herdsman Lake, WA, 2 October 2006. Note the hole in the soil above the tiger snake, site of a previous foraging attempt. The truncated tail of the snake is typical of many Herdsman Lake tiger snakes.



Figure 2. Close-up of Figure 1. The tiger snake was estimated to have burrowed its head up to 8 cm into the soil.



Figure 3. Further fossorial frog foraging by a western tiger snake, *Notechis scutatus*, at Herdsman Lake, WA, 5 November 2006. (Photo: N. David).



CAPTIVE REPRODUCTION AND LONGEVITY IN TAWNY CREVICE (*CTENOPHORUS DECRESII*) AND CENTRAL NETTED DRAGONS (*C. NUCHALIS*)

Michael McFadden and Peter S. Harlow
Taronga Zoo, PO Box 20, Mosman, NSW 2088.

INTRODUCTION

The genus *Ctenophorus* consists of a group of at least 22 species of small to medium sized dragons, with representatives inhabiting most semi-arid and arid regions of Australia (Wilson & Swan, 2003). The genus is quite diverse, with a range of species adapted to specialised habitats, including rocky outcrops, sandy plains and dunes, shrublands or salt lakes (Greer, 1989). These agamids are typically known for their relatively short lifespan and high reproductive output, being capable of producing multiple clutches in a year (Bradshaw, 1981).

The Tawny Crevice Dragon (*C. decresii*) is a medium-sized dragon (average snout-vent length 82 mm), found throughout the stony outcrops and rocky ranges of eastern South Australia east to Mutawintji National Park, NSW. It is restricted to rocky areas, where it basks on exposed rocks and shelters in narrow crevices. The Central Netted Dragon (*C. nuchalis*) is a larger member of the genus (average snout-vent length 115 mm), ranging throughout most of the drier regions of the continent, from central New South Wales and Queensland to the coast of Western Australia. It is a ground-dwelling species, basking on earth mounds or low-lying vegetation and retreating to burrows for shelter. In this paper, the captive reproduction of both *C. decresii* and *C. nuchalis* at Taronga Zoo, Sydney, is detailed, with notes on the longevity of these species.

HUSBANDRY

The *C. decresii* group maintained at Taronga Zoo were originally obtained as four sub-adult animals through the University of Sydney in 1998 and 1999 from Mutawintji

National Park. Following the death of one individual in August 2000, these animals were maintained as a trio of one male and two females on public exhibit in the 'Arid Zone' section of the zoo's reptile house. The glass-fronted display measured 69 cm (length) x 63 cm (width) x 140 cm (height). The substrate consisted of red desert sand over an artificial irregular red mock-rock floor. Cage furnishings included dead branches for basking and a clump of dead Spinifex grass (*Triodia* sp.) to shelter beneath.

The *C. nuchalis* group housed at the zoo originated from a group of 6 founders wild-collected in the Alice Springs region of central Australia in early 1995. These animals have also been maintained in the 'Arid Zone' section of the reptile house, in groupings of one male and one or two females. Their glass-fronted exhibit is 118 cm (length) x 63 cm (width), with branches and shrubs to a height of 140 cm. Cage substrate and furnishing are as described above for *C. decresii*.

Both species have been maintained at similar ambient temperatures controlled by the same heating and cooling system. Prior to October 2001, the ambient temperatures within exhibits were maintained using thermostatically controlled radiant heaters, set at approximately 28°C during the warmer months and 25-26°C throughout the cooler months. Since that date, exhibit temperatures have been controlled by an air-conditioning system. Between October and March, the ambient temperature in both exhibits is set at 28°C during the daytime, falling to ambient Sydney temperatures at night. Between April and September, the daytime temperature is set at 28°C, falling to 24-25°C at night. For additional heating and UV light requirements, one 300 watt Osram Ultra-Vitalux globe is

utilized for eight hours per day in each enclosure from 900 to 1700 hours. In the *C. decresii* enclosure, the light was suspended 40 cm above the closest basking site, providing a basking temperature of greater than 43°C. In the *C. nuchalis* enclosure, the globe was situated 35 cm above the highest available basking area, providing a basking temperature of greater than 44°C. Sunlights in the roof of the building above the exhibits permit natural photoperiod.

The diet of both species in captivity includes both invertebrates and vegetation. Three times a week, dragons were offered live invertebrates, which consisted mostly of crickets, but occasionally included moths, fly maggots or small locusts. Invertebrates are dusted with Rep-Cal calcium powder or Herpivite multivitamin powder on every second feed. Dragons were also offered a vegetable mix, comprising of an assortment of finely-chopped green, leafy vegetables and soft fruit. Both species always had access to fresh water provided in a small bowl in their enclosure. Enclosures were spot cleaned for faeces by keepers every day.

CAPTIVE REPRODUCTION IN *C. DECRESII*

Between 2000 and 2004, the breeding trio of one male and two females produced a total of nine clutches of eggs. Six clutches were laid by one female and three by the other. Clutch size varied from 3-6 eggs (average = 4.6 eggs), which is within the range of 3-7 eggs previously recorded for this species (Greer, 1989; Harlow, 2000). Eggs were deposited into a burrow constructed by the female in the sand if it had been moistened. If the sand was not moistened eggs were laid in dry sand under a clump of *Spinifex* grass (*Triodia* sp.). Mating was never observed.

Eggs were laid between late July and early November, although a peak in egg laying was recorded in September and October, with six of the nine clutches deposited during these months. Double-clutching was recorded for the same female in 2003 and 2004. On these occasions, the time interval between

clutches was 40 and 39 days respectively. This is similar to the 40 day inter-clutch period recorded for the closely-related Peninsula Dragon Lizard *C. fionni* (Johnston, 1999). Additionally, on both occasions, the second clutch contained two eggs less than the first clutch. In 2003, this female laid six eggs in September and four eggs in November, whilst in 2004, she laid five eggs in September and three eggs in October. Egg mass in one fertile clutch of six eggs averaged 1.45 g (range 1.40-1.56 g), which is higher than the average egg mass of 1.10 g previously recorded for wild *C. decresii* from the same population (Harlow, 2000).

Two clutches of eggs were incubated at Taronga Zoo. Eggs from these clutches were incubated at 30°C and 26.4°C in a refrigerated incubator. These were set up in one-litre plastic food containers in medium-grade vermiculite mixed with water at an equal weight ratio. Clear plastic sandwich wrap covered the top of the container to maintain humidity. Five of the six eggs incubated at 30°C successfully hatched 55-56 days after laying. The three eggs incubated at 26.4°C hatched after 89 days. From the eight hatchlings, the average snout-vent length was 32.1 mm (range 31-33 mm), total length was 86.9 mm (range 83-91 mm) and average mass was 1.48 g (1.41-1.57 g). As with egg mass, hatchling mass in our specimens was also much higher than the average mass range (1.03-1.18 g) recorded in hatchlings from wild-caught gravid females (Harlow, 2000). This may be due to the larger size reached by the dragons in captivity and the abundance of high-quality food available. The captive female responsible for laying these two clutches had a prepartum mass of 33.6 g and 36.7 g, compared to the average mass for wild-caught gravid females of 17.6 g (Harlow, 2000).

CAPTIVE REPRODUCTION IN *C. NUCHALIS*

Between 1995 and 2001, thirteen clutches of eggs were laid at Taronga Zoo, with one female responsible for eleven of these. No

mating was recorded. Eggs were typically laid in moistened red sand when provided. Clutch size ranged from 3-6 eggs, which is within the range of 2-6 previously stated for this species (Pianka, 1971a; Bradshaw, 1981). However, the average clutch size of 4.9 eggs in captivity was higher than the average clutch of 3.4 eggs recorded in the wild (Bradshaw, 1981). This may be due to the abundance of food in captivity. Average egg weight from a clutch of six eggs was 1.58 g (range 1.45-1.69 g).

Double clutching occurred on three occasions, with inter-clutch intervals of 37, 70 and 112 days. In the case of the 37 day inter-clutch interval, the second clutch of eggs was not fertile. Double clutching has previously been reported in captivity for this species, with an inter-clutch interval as short as 32 days (Klages, 1982). Pianka (1971b) found that second clutches in this species average nearly one egg more than the first clutch. In two of the three double clutches recorded here, the second clutch was one egg larger than the first, whilst clutch size was equal in the remaining clutch.

Eggs were deposited at various times throughout the year, with clutches laid in May, July, August, September, November, December and February. Peak laying period was in November and December, with five of the thirteen clutches laid in this period. This pattern of breeding behaviour indicates that *C. nuchalis* may breed at any time of the year under our captive set-up. Wild data indicates that *C. nuchalis* is highly seasonal with a long breeding season, between September and March, that is largely determined by the availability of resources (Bradshaw, 1991). By late summer, most wild adult *C. nuchalis* die (Bradshaw, 1986). In captivity, with access to unlimited food and year-round suitable temperatures, *C. nuchalis* appear to have longer lifespans and the capability to reproduce during any month.

Eggs from *C. nuchalis* at Taronga Zoo were prepared and incubated in the same manner described above for *C. decresii*. Data are available for incubation of seven of the

clutches, incubated at temperatures of between 27°C and 30°C (Table 1). Average incubation period for the seven clutches was 73 days (range 57-85 days). Hatchling measurement data are only available for one clutch. The average snout-vent length of four hatchlings was 34.3 mm (range 32-36 mm), average total length was 71.8 mm (range 69-80 mm) and average mass was 1.46 g (range 1.23-1.60 g).

LONGEVITY

A number of species within the genus *Ctenophorus* are noted for having a relatively short lifespan, often encompassing only one to two years in the field (Pianka, 1971b; Cogger, 1978; Dickman *et al.*, 1999). In a marked population of over 1000 animals, Bradshaw (1986) found that *C. nuchalis* is an annual species, with less than two per cent of individuals living beyond 12 months and no individuals ever reaching three years of age. These dragons typically die during the hot, dry, late summer after breeding has ceased (Bradshaw, 1986).

As of June 2007, a female *C. decresii* that was wild-collected in April 1998 is still alive, and has thus been in captivity for 9 years 2 months. As this animal was obtained as a sub-adult, it could be at least six months older. Additionally, this female was still producing fertile clutches of eggs after being at Taronga Zoo for 6 years 6 months. Two other females obtained at this time lived for 7 years 10 months and 2 years 4 months in captivity. The breeding male *C. decresii*, also obtained as a sub-adult, lived for 7 years 2 months in captivity at Taronga Zoo and was still fertilising clutches of eggs after 5 years 8 months. This species has previously been known to survive for extended periods in captivity. The Australian Museum maintained this species for 10 years in captivity, whilst Adelaide Zoo maintained wild-caught specimens for 6 years (G. Johnston, pers. comm.).

The longevity of *C. nuchalis* in captivity is also much longer than has been recorded in wild populations. Our longest-lived *C. nuchalis* of

known age is a currently alive male that hatched at the zoo in May 1998, making this lizard 9 years 1 month old at the time of writing. Another male *C. nuchalis*, wild-collected as an adult, lived for 8 years 3 months in captivity. The eldest female, also wild-collected as an adult, lived for 7 years in captivity. These latter two individuals produced fertile clutches of eggs up to 5 years after collection. This lifespan in captivity is at least four times that noted for maximum age in wild populations (Bradshaw, 1986).

The reason behind this extended longevity in captivity is presumably due to unlimited food and the absence of parasites, competition, predation and drought. Bradshaw (1986) indicated that the ultimate cause of death in wild *C. nuchalis* was chronic dehydration during late summer. Starvation also played a lesser role in females, after the stresses of producing multiple clutches. In captivity, water was always available and food was provided *ad libitum* to rapidly replenish depleted energy reserves after reproduction, allowing dragons to quickly regain condition. This can be seen by the high reproductive output of the captive dragons. The longest-lived *C. decresii* and *C. nuchalis* females produced six and eleven clutches, totalling 27 and 54 eggs, respectively during their lifetime.

ACKNOWLEDGMENTS

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Table 1. Egg incubation data for seven clutches of *C. nuchalis* laid at Taronga Zoo and incubated at 27-30°C between 1995 and 1999.

Date Laid	No. of eggs (No. hatched)	Incubation period (days)
4.xii.1995	5 (3)	78
9.xii.1996	6 (6)	57
6.vii.1997	6 (3)	85
23.ii.1998	4 (3)	70
4.v.1998	5 (5)	69
24.xii.1998	5 (2)	78
27.xi.1999	5 (5)	73

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HOPLODACTYLUS CRYPTOZOICUS (REPTILIA: DIPLODACTYLIDAE): EXTENSIONS TO DISTRIBUTION, HABITAT AND MORPHOLOGY

Tony Jewell

216 Ripponvale Road, RD 2, Cromwell, New Zealand.

Email: rattusjewelli@hotmail.com.

INTRODUCTION

The *Hoplodactylus granulatus* species-complex occurs widely in New Zealand. Although most populations have long been included in *H. granulatus* (e.g. Robb, 1980; Thomas, 1981), recent genetic studies involving allozymes and mitochondrial DNA have revealed a deep and complex phylogeny that supports the recognition of at least nine distinct taxa (Hitchmough, 1997 & unpub.). The species appear to be allopatric, each occurring in a restricted area, but they are difficult to detect and are poorly understood (Hitchmough, 1997 & unpub.).

Hoplodactylus granulatus (Gray, 1843) sensu stricto occurs in two forms, one in the upper half of the North Island, the other in the northern South Island. A species in the southern North Island currently requires resurrection from synonymy with *H. granulatus*, probably as *H. sylvestris* (Buller, 1881). *H. nebulosus* (McCann, 1955) is restricted to the Stewart Island archipelago. *H. kahutarae* Whitaker, 1985 is found in alpine habitat in the northern South Island. *H. cryptozoicus* Jewell & Leschen, 2004 occurs in the south-west South Island. Another four species from the western and southern parts of the South Island are undescribed, i.e. *H. sp.* 'Open Bay Islands', *H. sp.* 'cascade', *H. sp.* 'Roys Peak' and *H. sp.* 'southern forest' (Hitchmough, unpub.).

Hoplodactylus cryptozoicus is the most recently described member of the group and is one of the most poorly known species. It is closely related to *H. nebulosus* but is distinguished by a shorter tail, a smaller eye with a broad dark outline, a reduced amount of orange colouration on the tongue, distinctly smaller body scales, a frequent presence of irregular two-tone orange spots across the body, and a

lack of scattered dark specks from the general colour pattern. Further, the species occur on different islands.

Hoplodactylus cryptozoicus was described from a single population in the headwaters of the Spence Burn, Takitimu Mountains. The type locality is a scree slope situated in the alpine zone, well above the natural tree line. Although individuals appear to be relatively common at the type locality, they seldom emerge from within the deep and mobile scree, and so can be extraordinarily difficult to detect. This cryptozoic behaviour meant few individuals were available on which to base the description ($n = 7$: 1 preserved; 1 live in captivity; 5 live in the field) and together with the highly limited known range resulted in a conservation threat status of 'Nationally critical' (Hitchmough, 2002). This paper documents recent advances in knowledge about the distribution, habitat and morphology of *H. cryptozoicus*.

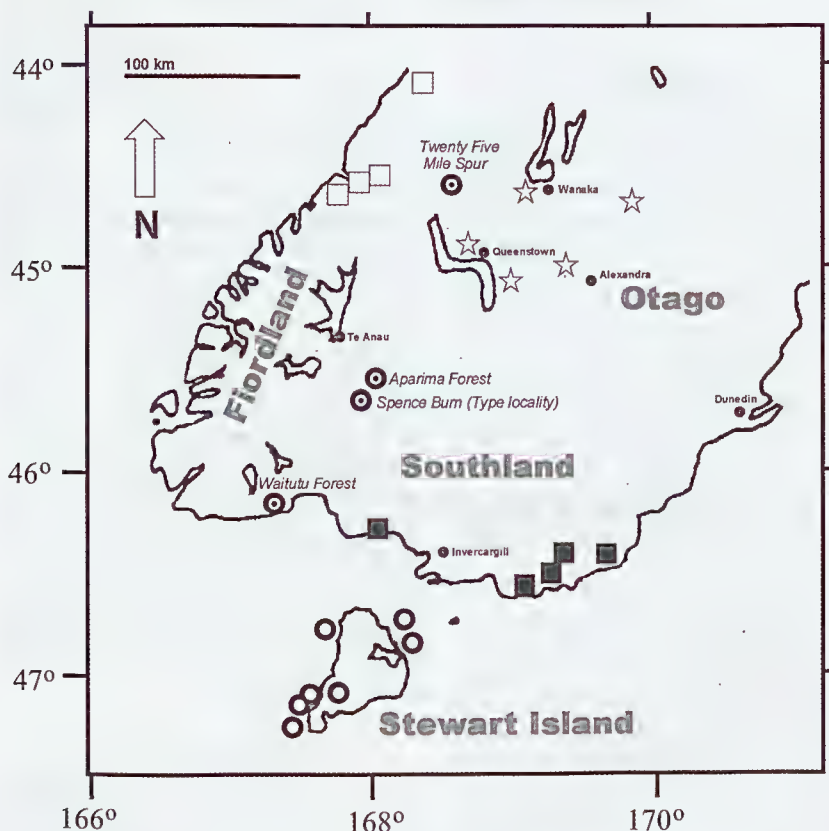
NEW POPULATIONS

In 2004, I collected a juvenile on Twenty Five Mile Spur in the Richardson Mountains, 130 km NNE of the type locality. In 2005, Mārk and Denise Wren photographed an adult female in Aparima Forest, 8 km ENE of the type locality. In 2006, Wayne Baxter and Keri Tuna collected a juvenile at the Percy Burn Viaduct in Waitutu Forest, south Fiordland, 70 km SW of the type locality. These localities are illustrated in Figure 1.

NEW HABITATS

In 2005, I found an adult female in a deeply fissured alpine rock bluff at the type locality (earlier records had all been from a scree slope). At this site the species has now been

Figure 1. Distribution of the *Hoplodactylus granulatus* species-complex in southern New Zealand. Closed circle with outline: *H. cryptozoicus* (locality names given); open circle: *H. nebulosus*; open square: *H. 'cascade'*; closed square: *H. 'southern forest'*; open star: *H. 'Roys Peak'*.



recorded between 1120-1200 m a.s.l. The Richardson Mountains specimen was found among scattered large rocks within alpine grassland habitat at 1450 m. The Aparima Forest specimen was found on the ground within dense beech (*Nothofagus* spp.) rainforest at 600 m. The Waitutu Forest specimen was found in a pile of timber in a small clearing within extensive lowland podocarp/hardwood rainforest (dominant tree species: *Dacrydium cupressinum*, *Metrosideros umbellata* and *Weinmannia racemosa*) at \approx 100 m (Figure 2).

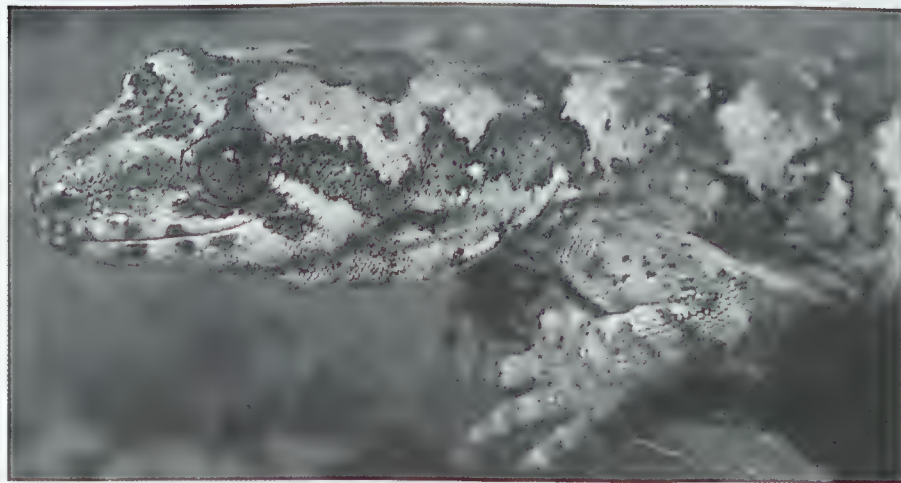
NEW MORPHOLOGICAL VARIATION

Based on a single photograph showing dorsal profile, the Aparima Forest specimen (illustrated by Jewell, 2006: 61) appears to be consistent with samples from the type locality. The Richardson Mountains specimen (illustrated by Jewell, 2006: 58-59) is again very similar, differing only in that the eye is pinkish and olive-grey (versus brown), and the general colour pattern involves scattered dark specks (versus absent or indistinct). The Waitutu Forest specimen (Figure 3) is more slender in general build, has a larger series of

Figure 2. Site where a *Hoplodactylus cryptozoicus* (Figure 3) was captured, at ≈ 100 m a.s.l. in the Waitutu Forest, southern Fiordland. The arrow points to a stack of timber in which the gecko was found. Photograph by Wayne Baxter and Keri Tuna.



Figure 3. *Hoplodactylus cryptozoicus* from lowland rainforest habitat (Figure 2) in the Waitutu Forest, southern Fiordland.



preloacal pores (34 wide, versus 23-28 wide), the mental and anterior labial scales are more elongate, the irregular 'orange-red' markings across the body are two-tone brick-red (versus two-tone orange or orange-brown), and again the general colour pattern involves some scattered dark specks.

NEW MATERIAL

A live adult male specimen held in captivity (see Jewell & Leschen, 2004) died in 2006 and was preserved at the Southland Museum & Art Gallery, with the registration number 0000.1. The Richardson Mountains specimen was maintained in captivity but escaped; it had dropped its tail when originally captured and this was preserved as a tissue sample (Hitchmough, unpub.). The Aparima Forest specimen was photographed and released immediately. The Waitutu Forest specimen was collected and I examined it live, then it was released at the site of capture; again it had dropped its tail which was collected as a tissue sample (Hitchmough, unpub.).

TAXONOMIC CONSIDERATIONS

Genetic data suggest that *H. cryptozoicus* and *H. nebulosus* are closely related and either separated very recently when compared to most other gecko species, or are more distant relatives which have undergone introgressive hybridization (Goodman *et al.*, 2005).

Until recently, southern Fiordland remained the only major biogeographic region, situated between or around these two taxa, from which representatives of the *H. granulatus* species-complex had not been available for examination. The new record from Waitutu Forest in southern Fiordland fills this gap in our knowledge. The specimen is in general less *nebulosus*-like (i.e. more slender and more brightly coloured) than are the other populations of *H. cryptozoicus*, and as such the possibility of finding a population with intermediate characteristics forming a cline linking the two species now seems remote. Further, the new observations confirm that most of the diagnostic traits separating the

species (i.e. tail length, body scale size/shape, colour pattern [except the scattered dark specks]; eye size and peripheral iris colour) are consistent within *H. cryptozoicus* over a broad span of distribution and habitat. These observations strengthen the argument for a taxonomic distinction between *H. cryptozoicus* and *H. nebulosus*.

DISCUSSION

Goodman *et al.* (2005) used genetic data to confirm that the Richardson Mountains specimen is *H. cryptozoicus*, but genetic data are not yet available for the Aparima Forest and Waitutu Forest populations. It is possible that the more distinctive Waitutu Forest specimen could represent a separate, cryptic species. However, it shares with *H. cryptozoicus* a unique combination of characters – grey tongue, short tail, minute body scales and bright colouration – that for the time being strongly support inclusion in this species.

One character used to separate *H. cryptozoicus* from *H. nebulosus* in the original description (Jewell & Leschen, 2004: fig. 4), i.e. the absence of scattered dark flecks, has proved to be inconsistent within *H. cryptozoicus*. This feature now appears to be unique to the type population. Also, general eye colour appears to be consistent in the southern populations only. However, as it is these populations that occur closest to *H. nebulosus*, this trait would still appear to be of value for identifying geographically proximate populations. Also, these new variations were observed among juvenile specimens and it is possible that they are lost at maturity.

Since 2004, the known distribution range of *H. cryptozoicus* has been extended from a single small scree slope, to a range of at least 200 km between northern and southern distribution limits. Most members of the *H. granulatus* species-complex appear to be allopatric or virtually so (R. Hitchmough, unpub.). Therefore, the occurrence of *H. nebulosus* on Stewart Island, *H. 'cascade'* in north Fiordland, *H. 'Roys Peak'* in Central Otago and *H. 'southern forest'* in coastal South-

land/Otago (see Figure 1) would suggest that *H. cryptozoicus* is restricted to the southern portion of Fiordland and the inland, western fringe of Southland/Otago.

The habitat range of *H. cryptozoicus* has been extended from "alpine scree" to "rainforest and rocky alpine habitats". Both records from forest environments result from the discovery of lone specimens on the forest floor. All known forest-dwelling members of the *H. granulatus* species-complex are arboreal, typically living in the forest canopy (R. Hitchmough, pers. comm.; T. Whitaker, pers. comm.), and this is almost certainly true of *H. cryptozoicus* too. The ongoing failure of searchers to find specimens in trees is likely to result from a combination of patchy (perhaps even rare) occurrence, occupation of a microsite (the canopy) that is usually inaccessible and difficult to search, and a secretive nocturnal behaviour.

The extensions to range and habitat that are reported here must alleviate the Nationally critical conservation threat status of *H. cryptozoicus*. However, the species remains poorly known and seldom encountered, and the impacts of introduced predatory mammals such as rodents, cats and mustelids are completely unknown. Because of these changes in our knowledge about the species and the huge knowledge gaps that they have highlighted, the former status of Nationally critical (Hitchmough, 2002) has been changed to Data deficient (Hitchmough *et al.*, 2006).

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PREDATION ON LIZARDS BY THE RED-BACK SPIDER, *LATRODECTUS HASSELTII*

Paul Orange,
18 Balfern Court, Hamersley, WA 6022.

Predation upon reptiles by the red-back spider, *Latrodectus hasseltii*, has been noted previously in the literature. De Rebeira (1981) and Orange (1990) report incidents of predation on snakes by the red-back (as *L. mactans*), and Koch (1980) and Mascord (1980) cite small lizards as prey items. Further observations on the ability of this spider to utilise reptiles as a food source are provided here.

OBSERVATIONS

An adult gecko, *Gehyra variegata*, was discovered dead in a red-back spider web on 16 January 1992, at Kambalda East (31°12'S 121°40'E), Western Australia. The web was situated inside a large shed. The *Gehyra* was discovered at about 2.40 pm and due to its nocturnal habits was assumed to have been captured the previous night. Usually, when *L. hasseltii* captures a terrestrial prey item it attempts to move it upwards, away from the ground and further into the web (De Rebeira, 1981; pers. obs.). However, in this instance the size and weight of the gecko appeared to have prevented this and the gecko was still in contact with the concrete floor of the shed. As a consequence the gecko was covered with small black ants.

Additional observations of red-back predation on lizards were made on a suburban property at Hamersley (31°51'S 115°47'E), a suburb of Perth, Western Australia.

On the evening of 26 January 2004, an adult *Hemiergis quadrilineata* (total length ca 90 mm) was discovered dead in a red-back web. From its condition it was assumed to have been captured the previous evening/night. The lizard had been successfully lifted up into the web and was situated 150 mm above the ground at its lowest point. At the time of the

observation (5.25 pm), the red-back was out of its retreat (a hole in a 'ventilation brick') and in the web, although not actually on the *Hemiergis*. After about five minutes it moved onto the lizard and commenced feeding at the head (Figure 1). It was still there about an hour later, although it appeared to have ceased feeding and moved off into its retreat at my close approach.

Later the same evening (9.10 pm) the red-back was back on the *Hemiergis*, apparently feeding again, but at the midbody this time. Once the spider was actually feeding, little seemed to disturb it and it could be approached quite closely (although I was careful not to actually touch the web or spider). This had been demonstrated earlier in the evening when I had taken a number of close-up flash photographs without disturbing it. However, if the spider was not feeding then it would retreat at my close approach.

This particular red-back had been in occupation of the ventilation brick (part of the exterior wall of a house) for a number of weeks prior to this incident. The hole it occupied was situated 200 mm above an area of brick paving. Despite the unlikely surroundings, the red-back captured another *Hemiergis* (snout-vent length 55 mm; total length 125 mm) on 31 January 2004. It was first noticed at 12.30 pm and seemed quite a recent capture – the previous night or early morning. It was somewhat larger than the first specimen, but despite this seemed to have been pulled slightly higher up into the web than the first. The first specimen was still located within the web, but the red-back appeared to have finished with it and it hung much lower than previously. Later, about 5.00 pm, the red-back was seen briefly on the *Hemiergis* but did not appear to feed. Upon examining the *Hemiergis* I noticed that its eyes were missing and I

could see right through the head (orbit to orbit), indicating that the brain was missing also – presumably ingested by the spider.

On 1 March 2005, in the same garden, a further *Hemiergis quadrilineata* was discovered in a red-back web. It was noticed at about 5.20 pm and from its condition was considered to have been killed the previous night. The web was quite extensive, covering an area on the ground about 350 mm by 200 mm, and located at the base of an ivy-covered brushwood fence. The outermost part of the web (furthest from the fence) was covered with spiderlings, recently hatched judging by their size and number. Confirmation of their recent emergence was seemingly provided a short time later when the adult female red-back appeared from her retreat carrying an empty egg sac in her jaws. She moved down the web until about level with the *Hemiergis* (ca 50 mm above ground level), and then let the empty egg sac drop. It fell almost to the ground before becoming entangled in the web, about 10 mm above the ground.

The female red-back then went to the *Hemiergis*, presumably to feed. However, the *Hemiergis* cannot have been very secure as it fell to the ground. Already on the ground, about 100 mm away, were the skeletal remains of a juvenile marbled gecko, *Christinus marmoratus* being picked over by the usual small black ants; almost as soon as the *Hemiergis* hit the ground the ants were onto it. The red-back descended to the *Hemiergis*, whether to feed or pull it back into the web, but was repelled by the ants. Whilst the ants did not appear to directly attack the red-back, she was extremely wary of them. She tried again a few minutes later, but the ants were in even greater numbers (10 to 20), and she retired. Judging by its appearance and proximity to the web, it is likely that the skeletal remains of the juvenile *Christinus marmoratus* were a previous prey item of the red-back.

In the most recent incident (14 February 2006) a red-back was discovered, apparently feeding, upon the carcass of a juvenile

Christinus marmoratus. This was during daylight hours (ca 5.00 pm), although as the web was located inside a small, windowless garden shed, it would have been quite dark. The web was situated close to the shed floor; the gecko had been hoisted up into the web and was suspended approximately 100 mm above the ground. It appeared to have been dead some time, being quite emaciated/dehydrated.

DISCUSSION

Hódar and Sánchez-Piñero (2002) found that the blackwidow spider, *Latrodectus lilianae*, discards the remains of lizards, removing them from the web once it has finished feeding. This, they postulate, helps to prevent ants from being attracted onto the web – an undesirable situation for the spider (ants are rejected as prey by blackwidows). Red-backs are similarly wary of ants, as exemplified by the alacrity with which the red-back in one case abandoned a *Hemiergis*. However, if the *C. marmoratus* carcass in the same case had been discarded by the red-back to prevent an influx of ants onto the web, it had also inadvertently attracted them to the vicinity of the web, enabling them to rapidly scavenge the *Hemiergis*. Similarly, the observation from Kambalda East suggests that red-backs try to raise their prey off the ground partly to prevent it from being reached by ants.

Red-backs, and other spiders, often seem to focus their attacks on the head-neck region of reptilian prey (De Rebeira, 1981; Orange, 1989). This may enable the spider to immobilize the most dangerous part of their prey (the jaws) whilst simultaneously attacking the most vulnerable part. It would seem natural then that the spider would commence feeding at this point once the prey was dead/subdued, as was seen in some of the observations reported here.

Red-backs are generally regarded as nocturnal (Köch, 1980; Mascord, 1980), but are sometimes active during daylight in the evening and in darkened areas (pers. obs.). The particular suburban garden that provided

most of the observations is well populated by lizards, in number of individuals if not number of species. Four species have been recorded to date (August 2002 to June 2007): *Cryptoblepharus plagiocephalus*, *Hemiergis quadrilineata*, *Menetia greyii*, and *Christinus marmoratus*. During this period, two species, *Christinus marmoratus* and *Hemiergis quadrilineata* have been recorded as prey items for red-backs, but not *Cryptoblepharus plagiocephalus* or *Menetia greyii*. Reasons for this are unclear and it may be that such an incident simply has not been witnessed as yet. Certainly there are similarities between those lizards recorded as prey for red-backs and those not: both *Hemiergis quadrilineata* and *Menetia greyii* are terrestrial, while *Christinus marmoratus* and *Cryptoblepharus plagiocephalus* favour "off-the-ground" vertical habitats (trees, fences and brick walls), but are also terrestrial (Greer, 1989; pers. obs.). Size doesn't appear to be a factor since all the lizards are within limits acceptable to *Latrodectus* (Hódar & Sánchez-Piñero, 2002; Koch, 1980; pers. obs.). Perhaps the most relevant difference between the two groups is that of activity times. *Cryptoblepharus plagiocephalus* and *Menetia greyii* are diurnal, whereas *Hemiergis quadrilineata* and *Christinus marmoratus* are crepuscular/nocturnal (Greer, 1989; pers. obs.), that is, when red-backs are most active. A similar correlation was noted by Hódar and Sánchez-Piñero (2002), in their study on the feeding habits of the related blackwidow spider, *Latrodectus lilianae*, in south-eastern Spain.

The apparent ease with which one red-back had managed to secure a second *Hemiergis* was quite disconcerting, but probably reveals as much about the habits of *Hemiergis quadrilineata* as it does the hunting capabilities of the red-back. The red-back web in this case was surrounded by an area of brick paving, with no discernable lizard cover other than an unkempt lawn 2 m away. This suggests that *H. quadrilineata* is quite a wide-ranging lizard under cover of darkness and, despite its much-reduced limbs, shows little

hesitation in crossing open areas. This is borne out by observation, as I have encountered *H. quadrilineata* active under such circumstances. However, the position of the web also reveals another aspect of the behaviour of *H. quadrilineata*. Like many small reptiles, it has a tendency to move along structures it encounters (hence the effectiveness of drift fences in pit-trapping). Whilst moving along the base of (in this case) an exterior house wall probably provides some protective cover for *Hemiergis*, it also places them at risk from red-backs that build their webs against such structures.

How frequently lizards fall prey to red-backs in this suburban garden is not known. The garden covers an area of 900 m² and is an unkempt, eclectic mix of introduced and native vegetation. As noted previously, all four species of lizard recorded are common within the garden; red-backs are encountered less often. This may be a reflection of their status as a predator, of less suitable microhabitats, or an example of observer bias (a kind of herpetological 'tunnel-vision' on the part of this observer – red-back webs being more noticeable when they contain a reptile). To date, a total of five lizards (two *Christinus marmoratus* and three *Hemiergis quadrilineata*) have been recorded in three red-back webs. From these observations it appears that once a red-back web is established in a suitable area it may represent a considerable threat to lizard traffic. However, in terms of overall impact on the lizard fauna of this garden, it seems unlikely that red-backs are having a significant impact. General opinion is that spiders play a relatively minor role in food webs (Hódar & Sánchez-Piñero, 2002), and the lizards remain as common as ever.

ACKNOWLEDGMENTS

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Figure 1. Red-back spider, *Latrodectus hasselti* feeding on the skink, *Hemiergis quadrilineata*.



HERPETOFAUNA OF THE MALABAR HEADLAND

Arthur W. White

Biosphere Environmental Consultants, 69 Bestic St, Rockdale, NSW 2216.

Email: awh41103@bigpond.net.au.

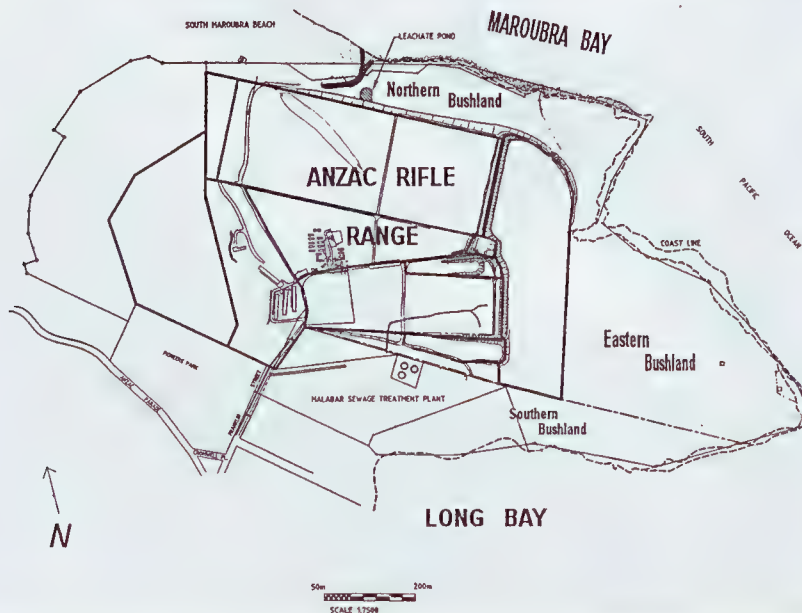
INTRODUCTION

Intact and reasonably undisturbed bushland areas containing representative herpetofauna are scarce in the Sydney metropolitan area (White & Burgin, 2004). Residential and industrial development in Greater Sydney has resulted in the loss of many bushland areas and the degradation of many of the surviving remnants. Often bushland only survives in tact if it has been gazetted for a particular purpose, such as a sewer or electricity easement or is protected as part of military land. The Malabar Headland, between Maroubra Bay and Malabar is an isolated area that is owned by the Commonwealth Government. The western section of the headland has been developed to become the Anzac Rifle Range

(Figure 1). The eastern section of the site is bushland but contains abandoned arsenals, tunnels and gun turrets constructed between 1939 and 1943 (RDHS, 1994). It also contains pill boxes and coastal surveillance posts. The ongoing military control of the site has prevented many other more destructive developments from occurring on the headland and large areas of coastal heath still survive around the crumbling military installations.

The Malabar Headland site has had public access since WWII although this has been limited to walking tracks. In the last 20 years a Friends of the Malabar Headland group has been carrying out bush regeneration works on site and so weed infestation and exotic plants have been controlled. In more

Figure 1. Map of Malabar Headland, showing location of the three bushland sites.



recent years, additional fences and barriers have been erected to prevent trail bikes and motorised vehicles from accessing the site. Horses are occasionally taken onto the site.

The combination of the high degree of protection of the site, ongoing bushland conservation and weed control works and limitations on public activities in the area has meant that the Malabar Headland contains some of the best coastal heath in Sydney, and has retained large elements of the original fauna. Fifty years ago, Malabar Headland was a favourite site in eastern Sydney for the observation and collection of reptiles and frogs (J. Cann, pers. comm.). Many herpetologists, including myself have scoured the bush on the headland in an effort to observe reptiles that have disappeared from similar areas in Sydney.

In 2003, the Commonwealth Government initiated a review of the future role of the Malabar headland (DEH, 2007). In order to assist with the collation of up-to-date information about the fauna on the headland, a range of fauna surveys were commenced, including that for reptiles and frogs.

SURVEY METHODS

The herpetofauna surveys reported on here were carried out in suitable weather conditions at various times between November 2003 and May 2007. Nocturnal surveys were carried out for frogs following recent rain while reptile searches were usually carried out on sunny mornings. No trapping methods were used in the surveys, instead opportunistic habitat searches and observations were employed. The headland is divided into three bushland areas (Figure 1) and the segment of capture was recorded for all animals caught or seen.

Each land segment was surveyed thoroughly at least once a year. In areas of thick heath, the ground vegetation was raked through using a long-handle rake and reptiles and frogs were unearthed and captured, identified and released. Around the old military structures, suitable vantage points were found early on sunny mornings and reptiles were observed using field binoculars; reptiles were

caught only if the identity of the animals was not readily apparent.

Frog surveys were carried out at night after rain. Areas where surface water collected after rain were visited and all calling frogs noted. Call playbacks were used to try to detect particular frogs in areas where habitat appeared suitable; the call of Green and Golden Bell Frog *Litoria aurea* and Wallum Froglet *Crinia tinnula* were played on many nights at several locations. Following the identification of all calling frogs, a ground search was carried out using headlamps. Frogs were only caught if they could not be immediately identified; they were released as quickly as possible at the site of capture. Disposable gloves were used when handling frogs, and boots and equipment were sterilised before entering and leaving the site to prevent the accidental spread of disease.

In May, November and February each year, diurnal tadpole surveys were carried out. At each 'water body,' tadpoles were collected using a long-handled net. The tadpoles were transferred to a plastic bag and identified using Anstis (2002). The tadpoles were released at the site of capture. Holding bags were not reused and all equipment was sterilised before and after leaving the site.

HISTORIC HERPETOFAUNA

Records of the reptiles and frogs from Malabar Headland are scarce and there are few museum specimens from there. In order to determine the past range of reptile species on the site contact was made with John Cann, a long time resident in the area and a renowned herpetologist. John was able to provide first hand lists of reptile species from the site dating between the 1950s and 1970s. Furthermore, he was able to recount earlier herpetological events made by his father, George Cann Senior, during the 1930s at Malabar. From these accounts, it was possible to prepare a reasonably complete list of the reptiles present on the site from seventy to eighty years ago. Unfortunately, the Canns did not keep written records of the frogs in the area and so it was not possible to repeat this exercise for that animal group.

The only historic frog records that were available were my personal records and most of these related to the wetland now known as Lake Malabar and the wetland on the northern side of the headland. John Cann was able to provide evidence of the presence of Green and Golden Bell Frogs from the wetland in the northern sector of the headland; these frogs were easily observed at the site until the late 1960s (J. Cann, pers. comm.).

RESULTS

Reptiles

Eleven lizards (including one pygopodid) and four snakes were detected on the headland (Table 1). The relative abundance of each species is presented in terms of the minimum number of sightings made over the two and half years of the survey, up to 100 sightings.

The presence of an apparently stable population of White's Skink (Figure 2) at Malabar Headland is noteworthy as this species has almost completely disappeared from bushland areas around Sydney (White & Burgin, 2004).

The list of species below was compared with the reptile species list derived from John Cann and the two lists differed by only one species; namely the Eastern Tiger Snake *Notechis scutatus*. These snakes were not common in the area but were detected on the site as late as the early 1960s. John Cann related the loss of Tiger Snakes from the site to the loss of swampland at the western end of the headland; this area was filled in at that time and later developed into sporting fields (Pioneer Park).

Table 1. Reptile Species detected at Malabar Headland.

Reptile Group	Species name	Common Name	Bushland Areas Found	Abundance (no. found)
Skinks	<i>Cryptoblepharus virgatus</i>	Wall Skink	E,N,S	57
	<i>Ctenotus taeniolatus</i>	Copper-tailed Skink	E,S	165
	<i>Egernia whitii</i>	White's Skink	E	33
	<i>Eulamprus tenuis</i>	Bar-sided Skink	N,E	12
	<i>Eulamprus quoyii</i>	Eastern Water Skink	E,N,S	189
	<i>Lampropholis guichenoti</i>	Garden Skink	E,N,S	53
	<i>Lampropholis delicata</i>	Grass Skink	E,N,S	123
	<i>Tiliqua scincoides</i>	Eastern Blue-tongue Lizard	E	14
Dragons	<i>Amphibolurus muricatus</i>	Jacky Dragon	E,N,S	44
	<i>Pogona barbata</i>	Eastern Bearded Dragon	E	7
Pygopodids	<i>Pygopus lepidopodus</i>	Common Scalyfoot	E,N	6
Elapid Snakes	<i>Demansia psammophis</i>	Yellow-faced Whip Snake	E,N	17
	<i>Hemiaspis signata</i>	Black-bellied Marsh Snake	E,N,S	29
	<i>Pseudechis porphyriacus</i>	Red-bellied Black Snake	E,N	12
	<i>Pseudonaja textilis</i>	Eastern Brown Snake	E	2

Figure 2. *Egernia whitii* from Malabar Headland.



Mackay (1954) reported that Broad-headed Snakes *Hoplocephalus bungaroides* were present at Long Bay and noted that "the last specimen to be caught in Sydney was at the old Randwick Rifle Range in 1934". Broad-headed Snakes were never encountered by the Canns at Long Bay.

Frogs

Six species of frogs were detected, three being tree frogs (Hylids) and three being Ground Frogs (Myobatrachids; Table 2).

My personal records for the area contained five of the six species listed below, plus one unlisted species. I have no records or recollections of *Litoria fallax* being present in the Malabar area prior to 1995. I have records (plus photos) of a *Uperoleia* frog from the western swamps of Malabar (Figure 3) which I tentatively called *Uperoleia laevigata*. Unfortunately, the photos do not adequately resolve the identity of this frog.

Green and Golden Bell Frogs are the only

Table 2. Frog species detected at Malabar Headland.

Frog Group	Species name	Common Name	Bushland Areas Found	Abundance (no. found)
Hylids	<i>Litoria dentata</i>	Bleating Tree Frog	N	>30
	<i>Litoria fallax</i>	Eastern Dwarf Tree Frog	N	>100
	<i>Litoria peronii</i>	Perons Tree Frog	E,N	>50
Myobatrachids	<i>Crinia signifera</i>	Common Eastern Froglet	E,N,S	>100
	<i>Limnodynastes dumerilii grayi</i>	Eastern Banjo Frog	E	>30
	<i>Limnodynastes peronii</i>	Striped Marsh Frog	E,N,S	>100

frogs previously known to have occurred at the Malabar Headland that have now disappeared from the site. These frogs were present in the wetland on the northern side of the Malabar Headland, as well as in the western swamp; the reason for their disappearance from these swamps is unexplained. The *Uperoleia* was found in the western swamps which were subsequently drained and filled in.

DISCUSSION

Reptile and Frog Biodiversity

Malabar Headland contains a representative collection of species that were apparently typical for that area, at least since the 1950s. Reptile and frog diversity is often greatly reduced near highly urbanised area (White & Burgin, 2004). The eastern section of Malabar Headland still contains large areas of coastal heath and scrub and has changed little over that period (J. Cann, pers. comm.). The most noticeable change on the headland has been the construction of sewer vents for the ocean outfall line from the Malabar Sewage Treatment Plant.

It appears that only two species of snake (*Notechis scutatus* and *Hoplocephalus bungaroides*) and two species of frog (*Litoria aurea* and *Uperoleia* sp.) have been lost from the area within living memory and this makes the headland an area of high local conservation value.

The Future of the Headland

In 2005, a Facility Management Plan was prepared (Coffey, 2005) for the headland. This report looked at future uses of the entire headland and recommended that the eastern bushland area should be dedicated as a conservation area. Apart from containing a representative selection of reptile and frog species, the site has relatively intact coastal vegetation communities and contains a roosting site for an endangered bat species (White, 2007). The biological values of the headland are currently being assessed by the Department of Environment and Conservation and the site has recently been listed as an Environmental Heritage Area (Department of Environment and Heritage).

Figure 3. *Uperoleia* sp. from Malabar Headland.



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OBSERVATIONS OF DIET OF LACE MONITORS (*VARANUS VARIUS*) IN GOSFORD, NEW SOUTH WALES

Meri Oakwood¹ and Leonard Marquart²

¹Envirotek, PO Box 25, Nana Glen, NSW 2450.

²416 Glenrock Parade, Point Clare, NSW 2250.

INTRODUCTION

The Lace Monitor *Varanus varius* is a large lizard ranging up to 2.25 m long (Swan, 1990) with body mass up to 14 kg (Weavers, 1988) that lives in the lowland forests of south-eastern Australia.

Radio-tracking has shown that Lace Monitors are diurnal, males have a mean home range of 65 ha and that they rarely venture far into cleared land (Weavers, 1993). They are generalist carnivorous predators and scavengers, feeding on a range of prey including mammals, birds, reptiles, insects and carrion (Weavers, 1989; Guarino, 2001). Here we report three opportunistic observations of the stomach contents of *V. varius* that were recorded during a survey for Spotted-tailed Quolls in the Gosford area, NSW.

METHODS

The survey was carried out in early summer, from 5-9 December 2005 at Kincumba Mt, Katandra Reserve and Rumbalara Reserve in Gosford. These reserves are surrounded by urban or semi-rural areas. One hundred wire cage traps (30 x 30 x 60 cm) were laid out along fire trails and roads, spaced approximately 200 m apart (i.e. spread along 19.6 kms) and set 10-50 m in from the edge of the road. Half of the traps were hook traps (Katandra/Rumbalara) and half were treadle traps (Kincumba Mt). GPS location was recorded for each trap. Traps were placed in sheltered positions, covered with a heavy plastic bag or hessian and baited with chicken wings on the first day. They were then left open for four days in succession and checked every morning.

RESULTS

Over 400 trap nights, Lace Monitors were caught on fourteen occasions. Land Mulletts (*Egernia major*) were caught on six occasions and Blue-Tongue Lizards (*Tiliqua scincoides*) on five.

Lace Monitors were caught on ten occasions in Kincumba Mt and four occasions at Katandra/Rumbalara Reserves. This difference between the sites may be due to an actual difference in abundance or it may be due to treadle traps being more successful at capturing this species of varanid.

Three of the lace monitors regurgitated their stomach contents. One at Kincumba Mt contained an unidentified bird. Of the other two, both at Katandra Reserve, one (9 December) had consumed a brown pigeon (*Macropygia amboinensis*) and the other (8 December) had consumed a rainbow lorikeet nestling (*Trichoglossus haematodus*), one juvenile rabbit and four baby rabbits (Figure 1). Both of these varanids were captured in eucalypt forest. The varanid that had consumed the rabbits was caught approximately 200-300 m from the nearest open grassed areas.

DISCUSSION

These observations of the consumption of two native bird species (one adult Brown Pigeon, one nestling Rainbow Lorikeet) and one introduced mammal species (five immature rabbits) are consistent with previous studies on the diet of *V. varius*. Weavers (1989), analysing scats and stomach contents ($n = 50$) from Lace Monitors mostly at Deva National Park (NSW) and Croajingolong NP (Victoria), found rabbits in 28% and birds in 16% of samples although only one contained

Table 1. Locations of goannas that regurgitated identifiable stomach contents

Date	GPS location	Description
8.xii.2005	349388/6300614	On track between western end of Clydes Rd and northern end of the quarry, Katandra
9.xii.2005	349403/6300762	On track between Clydes Rd and Toomeys Rd

feathers of a juvenile bird. Bird species identified with certainty were a Spotted Pardalote (*Pardalotus punctatus*) and a Pied Currawong (*Strepera graculina*). Guarino (2001) using scats and stomach contents ($n = 73$) of Lace Monitors at Lake Burrendong (NSW) found rabbit in 23% of samples and birds in 10%; nestling birds and rabbits were mainly eaten during spring and early summer. Bird species identified were Galah (*Cacatua roseicapilla*) and Wood Duck (*Chenonetta jubata*). Rose (1974) did not find birds in stomach contents of seven Lace Monitors from Kuringai Chase National Park (NSW), collected between September and December, but did report small mammal remains in one individual. Vestjens (1977a,b) examined stomach contents of 18 Lace Monitors at Lake Cowal (NSW), and found a bird (White-winged Chough, *Corcorax melanorhamphus*) in one, and rabbits in four; he also observed an instance of predation on chicks of the Little Pied Cormorant (*Phalacrocorax melanoleucos*).

The observations at Gosford confirm previous studies that Lace Monitors are opportunistic consumers of a wide range of prey and concur with Guarino (2001) that nestling birds and rabbits were mainly eaten in spring/early summer. These observations add two species of bird to the list of species in the literature that are known to be consumed by *V. varius*.

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Figure 1. Regurgitated stomach contents of a Lace Monitor *Varanus varius* in the Gosford region, New South Wales. Photo: M. Oakwood.



REPTILES AND AMPHIBIANS OF WADBILLIGA NATIONAL PARK AND ENVIRONS ON THE SOUTH COAST OF NEW SOUTH WALES

Garry Daly

Gaia Research Pty Ltd, PO Box 3109, North Nowra, NSW 2541.

Email: gaiaresearch@shoalhaven.net.au.

ABSTRACT

Systematic surveys for reptiles at 62 sites and amphibians at 51 streamside sites in Wadbilliga National Park and other areas on the far south coast of New South Wales were conducted between 1997 and 2004. A total of 24 species of reptile and 11 species of frog was detected during systematic surveys and an additional six species of reptile and seven species of frog were found opportunistically or during non-standard surveys. No members of the families Gekkonidae or Pygopodidae were detected. Quantitative data indicated that ridgelines had the richest species diversity of reptiles but gully sites had the highest density of reptiles. Range extensions of *Tympanocryptis diemensis* and *Egernia whitii* were recorded.

INTRODUCTION

Wadbilliga National Park (NP), Dampier State Forest (SF) and Buckenbowra SF are located on the south coast of New South Wales between 34°37' and 35°33' latitude and 150° and 150°35' longitude. Surveys of reptiles and amphibians were conducted in the broader region of the above mentioned management areas from 1997 to 2004.

Two previous studies on reptiles and amphibians have been conducted in the area; Goldingay, Daly and Lemckert (1996) studied the impacts of selective logging in the montane forests of Talloganda SF and Badja SF, and Wellington and Wells (1994) conducted surveys in the lower escarpment forests of Dampier SF and Wandella SF to prepare a species inventory. There have also been two targeted surveys of amphibians in the broader area: Daly, Pennay and Coombes (2002) conducted systematic searches for the

Stuttering Frog *Mixophyes balbus*, and Daly and Senior (2003) conducted surveys for the Green and Golden Bell Frog *Litoria aurea*.

The aim of the present paper is to document the regional distribution of reptiles and amphibians in relation to environmental variables. Quantitative surveys using standard survey methods allowed a measure of relative species diversity and abundance. The zoogeography of the herpetofauna is considered in the region.

METHODS

Reptiles and amphibians were surveyed in eight National Parks (NP), Nature Reserves and State Forests on the south coast of New South Wales. The study area formed a near contiguous block of bush south of the Kings Highway near Batemans Bay to Cobargo and west to Numeralla Mountain, Wadbilliga NP and Badja SF (Figure 1). The total area surveyed covered some 344000 hectares (Table 1).

Description of study area and environmental variables

The bulk of the study sites were within Wadbilliga National Park (NP), Badja NP, Dampier SF and Buckenbowra SF, which cover an area within the coastal hills and escarpment on the south coast of NSW. Elevations of reptile transects ranged from 5 to 1210 m (average 572 m, $n = 62$). Elevations of frog transects ranged from 5 to 1070 m (average 352 m, $n = 51$).

Geology and soil

The area had a variety of rock formations and geomorphology. The predominant geology of the area includes undifferentiated sediments, undifferentiated granite, Minuma Beds Conglomerate, Merrimula Group Sandstone, Comerong Volcanics and Sedimentary layer

Figure 1. Survey sites on the south coast and ranges of New South Wales. Triangles represent amphibian streamside search sites, squares represent reptile search sites. Black boundaries are national park estates.

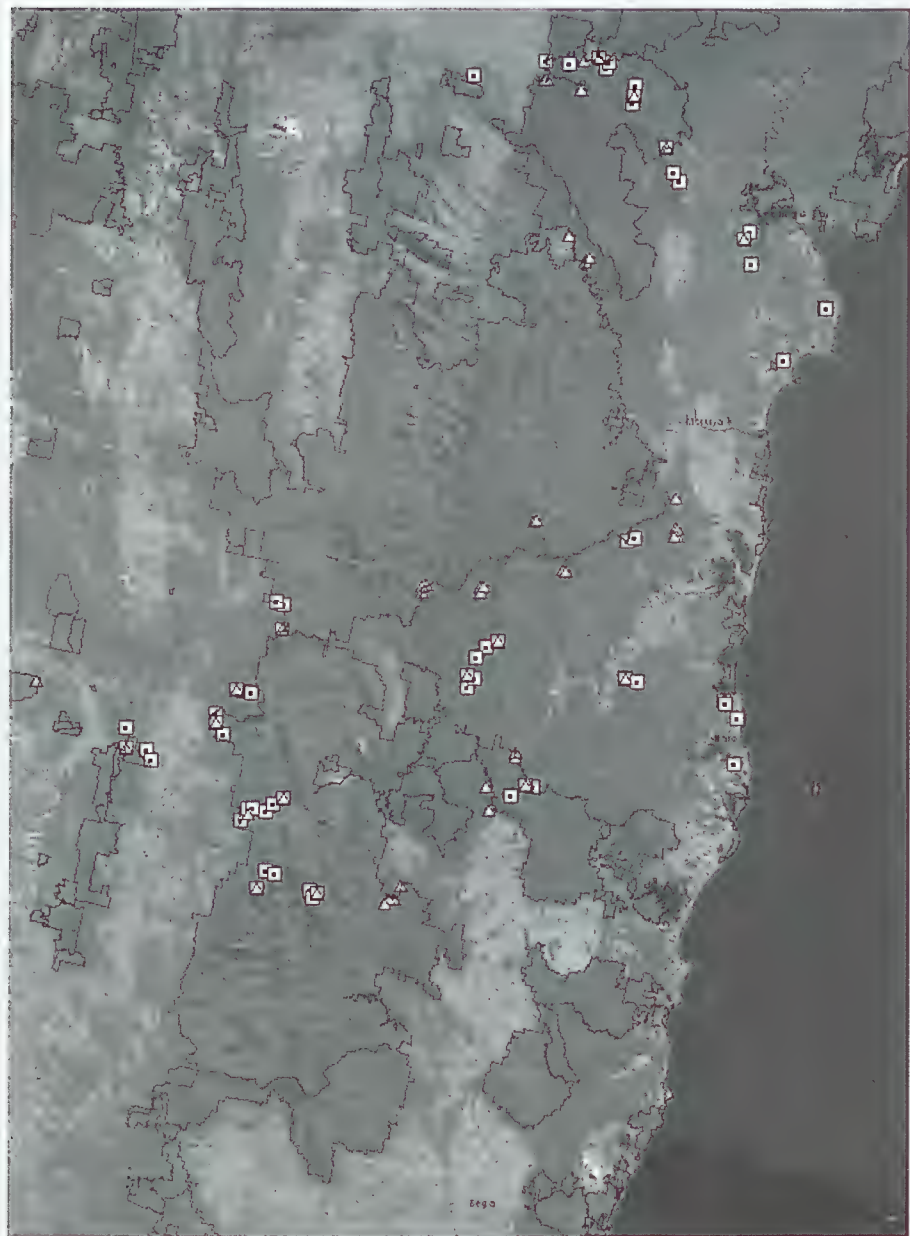


Table 1. Distribution of survey sites by reservation/State Forest in the south coast and ranges of New South Wales. † = targeted and opportunistic surveys.

Area surveyed	Total Area (ha)	No. Reptile Sites	Min. Elevation (m)	Max. Elevation (m)	Mean (m)	No. Frog Sites	Min. Elevation (m)	Max. Elevation (m)	Mean (m)
Badja SF	8244	8	920	1110	995	2	900	920	910
Bodalla SF	24241	3	35	150	85	1	35	35	35
Buckenbowra SF	5197	9	310	780	608	4	10	720	416
Dampier SF	37846	9	130	440	270	16	60	630	239
Deua NP	117243	†	-	-	-	2	70	80	85
Long Swamp	66	†	5	5	5	†	5	5	5
Mogo SF	15606	3	5	50	27	1	5	5	5
Monga NP	25116	3	720	750	730	5	680	710	700
Moruya SF	4519	3	55	160	95	6	30	60	43
Wadbilliga NP	97761	13	570	1210	995	9	260	1070	621
Wandella SF	5501	0	-	-	-	2	90	110	100
Crown land	2500	2	890	1100	1100	0	-	-	-
Freehold	155	9	5	1005	299	3	50	810	320
Total	343995	62				51			

and Coondella Creek Devonian Granite (Canberra and Bega Geology GIS). The western escarpments of Monga, Buckenbowra SF and Wadbilliga NP are prominent features in the landscape.

Most of the study area was steep and had thin soils. The exceptions were the western edge of the area which contains deeper, higher nutrient soils of the southern tablelands and around Badja and Conway's Gap which had deep volcanic soil. On the coastal plain the soils were generally heavy, except beside creeks and the coastal fringe where light sandy soils of depositional landscapes were present.

Vegetation communities at survey sites

The vegetation communities in the study area varied with respect to biophysical factors such

as altitude (temperature), soils depth, soil moisture and nutrient level. Classification and mapping of these communities is documented in Thomas *et al.* (2000). The sites surveyed on the escarpment consisted of forests dominated by *Eucalyptus fastigata*, *E. fraxinoides*, *E. seiberi*, *E. rubida*, *E. radiata* and *E. pauciflora*. The higher nutrient, deeper soils generally supported species such as *E. fastigata* and *E. cypellocarpa* whereas ash forests (*E. seiberi*, *E. fraxinoides*) were associated with sites located on shallow lower nutrient soils. At lower altitude the vegetation communities were often dominated by *Corymbia maculata*, *E. longifolia* and *E. pilularis* (Table 2).

Variation of habitat between plots

The locations of survey sites were stratified by geology. Transects were also placed in three broad topographic positions being gully,

Table 2. Vegetation associations at survey sites in select forests.

Area surveyed	Major canopy species at sites
Badja SF	<i>Eucalyptus fastigata</i> , <i>E. fraxinoides</i> , <i>E. seiberi</i> , <i>E. rubida</i> , <i>E. radiata</i> , <i>E. pauciflora</i>
Bodalla SF	<i>Eucalyptus longifolia</i> , <i>Corymbia maculata</i> , <i>E. mulleriana</i> , <i>Angophora floribunda</i> , <i>E. seiberi</i> , <i>E. longifolia</i> , <i>E. botryoides</i> x <i>saligna</i>
Buckenbowra SF	<i>Eucalyptus seiberi</i> , <i>E. radiata</i> , <i>E. fastigata</i> , <i>E. cypellocarpa</i> , <i>E. maidenii</i> , <i>E. globoidea</i> , <i>Ficus rubiginosa</i> , <i>E. mulleriana</i> , <i>Doryphora sassafras</i>
Dampier SF	<i>Eucalyptus globoidea</i> , <i>Corymbia maculata</i> , <i>E. agglomerata</i> , <i>E. eugenoides</i> , <i>E. fastigata</i> , <i>E. cypellocarpa</i> , <i>E. bosistoana</i> , <i>E. elata</i> , <i>E. muelleriana</i> , <i>Angophora costata</i>
Mogo SF	<i>Corymbia maculata</i> , <i>Eucalyptus longifolia</i> , <i>E. globoidea</i> , <i>E. pilularis</i> , <i>Angophora floribunda</i>
Monga NP	<i>Eucalyptus fastigata</i> , <i>E. mulleriana</i> , <i>E. seiberi</i> , <i>E. radiata</i> , <i>E. nitens</i>
Moruya SF	<i>Eucalyptus mulleriana</i> , <i>E. paniculata</i> , <i>E. bosistoana</i> , <i>E. longifolia</i> , <i>E. elata</i> , <i>Angophora floribunda</i>
Wadbilliga NP	<i>E. dalympleana</i> , <i>E. pauciflora</i> , <i>E. radiata</i> , <i>E. fastigata</i> , <i>E. viminalis</i> , <i>E. fraxinoides</i> , <i>E. rubida</i> , <i>E. moorei</i> , <i>E. nitens</i> , <i>Acmena smithii</i>
Numeralla area Crown & freehold	<i>Eucalyptus dives</i> , <i>E. viminalis</i> , <i>E. mannifera</i> , <i>E. pauciflora</i>
Freehold near the coast	<i>Corymbia maculata</i> , <i>Eucalyptus longifolia</i> , <i>E. globoidea</i> , <i>E. pilularis</i> , <i>Angophora floribunda</i>

ridge and midslope. The topographic variation attempted to sample a variation in habitat based on moisture gradient (Table 3). Transects were separated by a minimum of 200 m (usually over one kilometre) and located within 50 - 1000 m of dirt roads or fire trails. The location (Australian Grid Reference 66 datum) of sites was determined by either a geographic positioning system or topographic maps.

Survey methods for reptiles

Reptile searches involved observing active animals as they basked or foraged, lifting loose rock and logs, decorticating bark and searching leaf litter. The search technique varied according to the habitat present at each site. In areas where there was a general

absence of loose rock and downed timber the survey involved searching for active animals.

Systematic surveys were based on sampling an area of approximately 100 x 200 m (two ha). Surveys were conducted for 60 minutes by one person or 30 minutes by two people. A total of 60 minutes search effort was maintained. The methods follow those determined by the NSW National Parks and Wildlife Service (NPWS) for the purpose of the comprehensive regional assessment (CRA) of forests in southern NSW.

A total of 62 sites were surveyed during late spring, summer to autumn between 1997 and 2004. Surveys were conducted between 802 and 1510 hrs EST at temperatures that ranged between 10-27°C. The location of survey sites is presented in Appendix A.

Table 3. Number of diurnal reptile survey sites and topographic positions. Altitude is average then (range) in metres.

Topographic Position	No. sites	Altitude (AHD)
Ridge	22	620 (20 - 1190)
Midslope	19	622 (5 - 1210)
Gully	21	487 (5 - 1070)
Total reptile searches	62	
Cage trapping Ridge	10	430 (20 - 1100)
Cage trapping Midslope	7	405 (5 - 1050)
Cage trapping Gully	26	262 (5 - 920)
Total cage trapping	26	

Cage trapping was conducted for goannas at 26 of the sites (Table 3). The cages (200 x 200 x 450 mm) were baited with chicken or sardines/oats/peanut butter and set for three consecutive days (except the targeted trap which was set for a single day). Traps were checked daily in the early morning.

Reptiles observed while conducting nocturnal frog searches, when travelling to and from sites or outside the survey period were recorded as opportunistic sightings.

Amphibian surveys

Nocturnal streamside survey sites were placed over a range of altitude (range of 5-1070 m, average 353 m) and vegetation communities. Searches were conducted between 1997 and 2003. Non-systematic surveys were conducted from 1995 to 2004 and often involved targeted diurnal surveys for *Litoria aurea* and tadpoles of *Mixophyes balbus*. Frogs detected while conducting reptile surveys were recorded.

Diurnal searches for amphibians

Diurnal surveys involved walking along creeks or beside dams/swamps in order to find frogs, tadpoles and/or spawn. Identification to species level was achieved by recognition of species-specific call, tadpoles and spawn. The calls of *L. aurea* were broadcast

from a cassette player while conducting diurnal searches in coastal areas.

Nocturnal surveys for amphibians

Nocturnal searches of 19 sites involved spotlighting approximately 250 m of creek with the aid of 50 watt/12 volt spotlights to observe frogs, tadpoles and spawn. These surveys were conducted in late spring to summer in 1997 and 1998 between 1900 and 2235 hours EST at temperatures ranging between 10-19°C (air). These surveys were conducted over a range of vegetation communities and seasons in order to collect data on a range of species. The methods followed those determined by the NSW NPWS for the purpose of the CRA of forests in southern NSW.

Thirty two targeted searches for *Mixophyes balbus* were conducted using a modified version of the CRA methods. The difference being that the broadcast of pre-recorded calls of the target species were continually played via a Walkman while surveying (Daly, Pennay & Coombes, 2002). The search effort for these surveys totalled 16.5 hours and the location of the total 51 sites is given in Appendix B.

Searches for *Lit. aurea* along the coastal plain were not of standard intervals because they

were conducted around swamps, which varied in size. The search effort for these surveys totalled 14 hours and covered 60 sites. These searches also employed the broadcast of pre-recorded calls of the target species via a Walkman while conducting spotlight searches (Daly & Senior, 2003). Nocturnal searches were also made for frogs at fire dams and ponds (ca 20) created from quarrying activities. These searches involved spotlighting and identifying species by call.

Survey hygiene

For surveys conducted after 2001 the Wellington and Haering (2001) hygiene guidelines for the control of disease in frogs were complied with.

RESULTS

Plot data and opportunistic observations

A total of 699 individuals covering 24 species of reptile was observed during 62 hours of systematic survey (Table 4) and an additional six species were detected opportunistically or during targeted surveys. Four species of reptile accounted for about 80% of detections, these were *Lampropholis delicata* (26%), *Eulamprus heatwolei* (23%), *E. tympanum* (16%) and *L. guichenoti* (15%). No goannas were caught in the cage traps. On several high altitude transects *E. heatwolei* and *E. tympanum* were broadly sympatric. Black Snakes *Pseudechis porphyriacus* caught near Numeralla had black coloured ventral scales.

A total of 246 individuals covering 11 species of frog were detected during 31.5 hours of nocturnal streamside systematic surveys. Three species of frog contributed to about 84% of detections, these were *Crinia signifera* (43%), *Lit. nudidigitus* (30%) and *Lit. lesueurii* (11%). Calling male *Mixophyes balbus* were detected on three transects (two creeks) (Daly et al., 2002). A total of 1175 individuals from 12 species was detected during nocturnal searches of coastal swamps. Six species of frog contributed to about 89% of detections, these were *Limnodynastes peroni* (41%), *Lit.*

dentata (15%), *Crinia signifera* (10%), *Uperoleia tyleri* (9%), *Litoria peroni* (7%) and *Lit. ewingii* (7%).

Environmental gradients and species assemblages

The physiographic components of altitude (and hence temperature), presence of rock outcrops and creeks/swamps had a bearing on species diversity and zoogeography.

An assemblage herein termed highland species, which included *Egernia cunninghami* (Southern Tablelands form), *Pseudemoia coventryi*, *Pseudemoia entrecasteauxii*, *Pseudemoia spenceri*, *Tiliqua nigrolutea*, *Austrelaps ramsayi* and *Uperoleia laevigata*, was detected above 750 m AHD. In contrast *Eulamprus quoyii*, *Morelia spilota*, *Lit. fallax*, *Lit. jervisiensis*, *Uperoleia tyleri* and *Paracrinia haswelli* were only detected at relatively low altitude (below 310 m AHD).

More species of reptile were found at ridge, than gully or midslope sites (total species 18 vs 15 vs 14 for ridge vs gully vs midslope). However, when data were corrected for the unequal number of sites for each habitat, there was no significant difference between the numbers of species per site (average number of species per site 2.4 for ridge, 2.7 for gully, 2.8 for midslope; ANOVA: $F_{2,59} = 0.417$, $p = 0.661$). On average more individuals were detected on gully than midslope or ridge sites (average number of individuals per transect 12.9 vs 10.8 vs 10.0) (Table 4). Saxicolous species primarily found at ridge sites included *Bassiana platynota*, *Egernia cunninghami* and *E. whitii*.

A group of frogs were found to be facultative stream breeders. These were *Lit. citropa*, *Lit. lesueurii*, *Lit. nudidigitus* and *M. balbus*. The frogs that were only found in association with coastal wetlands/dams were *Lit. jervisiensis*, *Lit. fallax*, *P. haswelli* and *U. tyleri* (Table 5). The other species were detected in a variety of habitats such as farm dams, wetlands and ephemeral ponds over a range of altitudes.

Limnodynastes tasmaniensis was detected

Table 4. Number of reptiles observed during systematic surveys. X = observed opportunistically.

Family	Species	Common name	Ridge n=62	Midslope n=19	Gully n=21	Total n=62
Chelidae	<i>Chelodina longicollis</i>	Long-necked Tortoise	0	0	0	X
Varanidae	<i>Varanus varius</i>	Lace Monitor	1	0	0	1
Agamidae	<i>Amphibolurus muricatus</i>	Jacky Dragon	1	0	1	2
	<i>Physignathus lesueurii howitti</i>	Gippsland Water Dragon	0	0	1	1
	<i>Tympanocryptis diemensis</i>	Mountain Dragon	2	0	0	2
Scincidae	<i>Bassiana platynota</i>	Red-throated Skink	0	1	1	2
	<i>Egernia cunninghami</i>	Cunningham's Skink	2	0	0	2
	<i>Egernia saxatilis</i>	Black Rock Skink	13	1	1	15
	<i>Egernia whitii</i>	White's Skink	0	0	1	1
	<i>Eulamprus heatwolei</i>	Southern Water-skink	29	27	98	154
	<i>Eulamprus quoyii</i>	Eastern Water-skink	0	0	6	6
	<i>Eulamprus tenuis</i>	Barred-sided Skink	3	0	0	3
	<i>Eulamprus tympanum</i>	Highland Water-skink	22	28	29	79
	<i>Hemiergis decresiensis</i>		1	4	0	5
	<i>Lampropholis delicata</i>	Dark-flecked Sunskink	76	51	46	173
	<i>Lampropholis guichenoti</i>	Pale-flecked Sunskink	40	64	67	171
	<i>Nannoscincus maccayi</i>	Maccay's Skink	5	6	2	13
	<i>Pseudemoia coventryi</i>		1	5	2	8
	<i>Pseudemoia entrecasteauxii</i>	Woodland Tussock Skink	5	2	0	7
	<i>Pseudemoia spenceri</i>	Spencer's Skink	8	11	4	23
	<i>Saproscincus mustelinus</i>	Weasel Skink	11	4	10	25
	<i>Tiliqua nigrolutea</i>	Blotched Bluetongue	0	0	0	X
	<i>Tiliqua scincoides</i>	Common Bluetongue	0	0	0	X
Boidae	<i>Morelia spilota spilota</i>	Diamond Python	0	0	0	X
Elapidae	<i>Austrelaps ramsayi</i>	Highland Copperhead	1	0	0	1
	<i>Drysdalia rhodogaster</i>	Masters' Snake	0	1	0	1
	<i>Notechis scutatus</i>	Tiger Snake	0	0	0	X
	<i>Pseudechis porphyriacus</i>	Red-bellied Black Snake	0	0	2	2
	<i>Pseudonaja textilis</i>	Eastern Brown Snake	0	0	0	X
	<i>Rhinoplocephalus nigrescens</i>	Small-eyed Snake	1	1	0	2
Total Individuals			222	206	271	699
Total Species			18	14	15	

Table 5. Number of frogs detected during systematic surveys of streams and coastal wetlands. X = observed opportunistically.

Family	Species	Common name	Total streamside search	Total coastal wetlands
Hylidae	<i>Litoria citropa</i>	Blue Mountains Tree Frog	3	0
	<i>Litoria dentata</i>	Bleating Tree Frog	0	171
	<i>Litoria ewingii</i>	Ewing's Tree Frog	4	81
	<i>Litoria fallax</i>	Dwarf Tree Frog	0	3
	<i>Litoria jervisiensis</i>	Jervis Bay Tree Frog	0	48
	<i>Litoria lesueurii</i>	Lesueur's Frog	28	0
	<i>Litoria nudidigitus</i>	Leaf Green Tree Frog	75	0
	<i>Litoria peronii</i>	Peron's Tree Frog	5	83
	<i>Litoria verreauxii</i>	Verreaux's Tree Frog	3	52
Myobatrachidae	<i>Crinia signifera</i>	Common Eastern Froglet	106	118
	<i>Paracrinia haswelli</i>	Haswell's Frog	0	X
	<i>Limnodynastes peronii</i>	Striped Marsh Frog	9	487
	<i>Limnodynastes dumerilii</i>	Pobblebonk	1	3
	<i>Limnodynastes tasmaniensis</i>	Spotted Grass Frog	0	4
	<i>Mixophyes balbus</i>	Southern Barred Frog	3	0
	<i>Pseudophryne bibronii</i>	Bibron's Toadlet	9	15
	<i>Pseudophryne dendyi</i>	Southern Toadlet	X	0
	<i>Uperoleia laevigata</i>	Smooth Toadlet	0	X
	<i>Uperoleia tyleri</i>	Tyler's Toadlet	0	110
Total Individuals			246	1175
Total Species			12	12

around farm dams and swamps on the tableland near Numeralla and a few scattered locations near Moruya. *Litoria fallax* was only detected in constructed ponds near human habitation. Both species occurred on relatively flat land. *Limnodynastes dumerilii* was detected in a few coastal wetlands (Trunketabella and Pedro Swamp) and on top of the escarpment beside dams and creeks (Badja SF). Specimens examined from the latter area were *Lim. dumerilii dumerilii* whereas those found on the coastal areas were *Lim. dumerilii insularis*.

Threatened and regionally significant species

Two tadpoles of *M. balbus* and two calling males were detected at Big Belimba Creek. The habitat characteristics of these sites have been described elsewhere (Daly *et al.*, 2002). No *M. balbus* tadpoles or calling adults were found at this site during follow-up surveys in January 2000 and no tadpoles observed in May 2002.

No *Lit. aurea*, *Lit. littlejohni* or *Heleioporus australiacus* were detected although these

species were previously reported to occur in the survey area (NPWS Wildlife Atlas records, Wellington & Wells, 1994; Lemckert et al., 1998; Penman et al., 2004).

Species that were rarely detected included *Egernia whitii* (coastal population at Long Beach and near Numeralla Mountain) and *Morelia spilota* (one road killed specimen).

DISCUSSION

Species diversity and density

The present study recorded a total of 30 (24 during systematic surveys) species of reptiles and 19 (12 during nocturnal streamside searches) amphibians over a wide range of altitude. In comparison Wellington and Wells (1994) detected 14 reptile and nine species of amphibian in Wandella and Dampier SF. Wellington and Wells (1994) conducted reptile searches for periods of approximately 60 minutes over thirty three, 200 m transects so their search area and effort was similar to the current assessment. Like the current survey, transects were positioned in ridge, midslope and gully sites. *Cryptoblepharus virgatus* and *Heleioporus australiacus*, detected by Wellington and Wells (1994), were not found during the present survey.

Goldingay et al. (1996) detected 27 species of reptile and 14 species of frog at Tallaganda-Badja State Forests and environs. A subset of fifteen species of reptile was found during 100 minute searches of twenty, 500 m transects. Four species of reptile detected during that survey, *Pogona barbata*, *P. pagenstecheri*, *P. duperreyi* and *D. coronoides*, were not found during the current survey (identity of *P. pagenstecheri* confirmed by W. Osborne). This included one *P. barbata* observed outside the state forests in woodland near Numeralla, one *P. pagenstecheri* and one *P. duperreyi* within Tallaganda and Badja SF respectively and two *Drysdalia coronoides* near Tallaganda SF (pers. obs.). *Litoria booroolongensis* recorded as occurring in the area by Goldingay et al. (1996) is now considered to have been juvenile *L. lesueurii* (pers. obs.). *Litoria*

phyllochroa is now recognised as *L. nudidigitus* (Donnellan et al., 1999) and *Pseudophryne dendyi* from the Tallaganda/Badja area is now considered by the author to be a form of *P. bibronii* (see below).

This study found more individual reptiles on gully sites than midslope or ridge sites (average number of individuals per transect 12.9 vs 10.8 vs 10.0) (Table 4). Wellington and Wells (1994) similarly found on average more reptiles per transect at gully vs ridge vs midslope sites (10.5 vs 4.1 vs 3.3). They found similar numbers of species at gully, midslope and ridge sites (total species 8 vs 7 vs 6), as in this study, although species diversity was lower. The higher species diversity of reptiles in the current study is partly a reflection of the large number of sites, covering a wider altitudinal range. However, the average number of individuals found at each site in the current study was also considerably higher.

In contrast to the present study, other quantitative surveys of reptiles in temperate south-eastern Australia (NPWS, 2002; Daly, 2004, 2006) have found that ridge sites, especially those containing rock outcrops, have higher species diversity than gully and then midslope sites.

In the study area reptile density was positively correlated with moisture gradient. However, this was mainly due to a few species (water skinks *Eulamprus* spp., and *L. guichenoti*) being more abundant in gully sites. Wellington and Wells (1994) also found more water skinks and *L. guichenoti* in gully than midslope or ridge sites but in contrast Goldingay et al. (1996) found no significant difference in reptile abundance due to moisture (but a highly significant difference due to logging). Wellington and Wells (1994) conducted their survey at relatively low altitude (100-800 m) compared to Goldingay et al. (1996) (700-1200 m). The difference in altitude may have a bearing on the results presented by Goldingay et al. (1996). Data indicate *L. guichenoti* was abundant at low altitudes but uncommon

above 700 m. The variation in density of one common species to altitude suggests caution when assessing impacts from disturbance such as logging over a broad area.

Fossorial skinks were not common and *H. decresiensis* and *N. maccoyi* accounted for only 3% of individuals. Goldingay *et al.* (1996) found *N. maccoyi* on 14 of the 20 transects sampled and 13% of observations. Wellington and Wells (1994) detected one *N. maccoyi* representing 0.2% of observations. In the study area *H. decresiensis* was only found at high altitude in woodland habitats whereas *N. maccoyi* was associated with moist tall open forests, particularly above 700 m AHD.

The present study recorded no species of gecko or legless lizard. Wellington and Wells (1994) and Goldingay *et al.* (1996) also failed to detect geckos and legless lizards. Geckos may be absent from this region and although records indicate *Pygopus lepidopus* exists in this region it is rare. Other species that were infrequently detected or had patchy distributions included *Tympanocryptis diemensis* (freehold land near Numeralla Mountain and Dampier SF), *Egernia cunninghami* (freehold land near Numeralla Mountain), *E. whitii* (freehold land near Numeralla Mountain and Long Swamp near Bermagui), *Eulamprus tenuis* and what the author assigned to *Pseudophryne dendyi* based on marking (Bodalla SF).

The most common species of amphibian found was *Limnodynastes peronii*. This species was abundant in coastal wetlands but infrequently detected during streamside searches. Other common species found beside coastal wetlands were *Litoria dentata*, *Uperoleia tyleri* and *Crinia signifera*. Only the latter species was regularly detected calling beside streams.

There was a difference in the species of frog detected beside creeks than coastal wetlands. Species confined to creeks and soaks included *Lit. citropa*, *Lit. lesueurii*, *M. balbus* and *Pseudophryne dendyi*. Species only detected

beside coastal wetlands included *Lit. dentata*, *Lit. fallax*, *Lit. jervisiensis* and *U. tyleri*.

This study failed to detect *Lit. littlejohni* and *H. australiacus*, even though the tadpole phase of both species can take 12 months (Daly, 1996; unpubl. data) to complete transformation. Wellington and Wells (1994) found one *H. australiacus* in Wandella SF while White *et al.* (1994) examined museum specimens of *Lit. littlejohni* taken from Wadbilliga and Mt Dromedary which are within the survey area. These species are rare in this region and appear to have very patchy distributions.

Species assemblages and zoogeographic patterns

There are certain reptiles and frogs that when grouped can be considered zoogeographically as suites that reflect common associations with biophysical components. One group herein termed saxicolous species was highly associated with rock outcrops and sandy substrates in the region surveyed. The saxicolous species were *Egernia saxatilis*, *E. cunninghami* (Southern Tablelands form), *E. whitii* and *Bassiana platynota*, although *E. saxatilis* was also found under bark and split logs in fallen timber and the Southern Tablelands form of *E. cunninghami* can also take refuge in split fallen logs (pers. obs.).

The highland species found at elevated sites in the western portion of the study area were also detected by Goldingay *et al.* (1996) but not Wellington and Wells (1994) who surveyed at lower altitudes. *Limnodynastes tasmaniensis* was detected at high altitude on the southern tablelands and a population found at low altitudes in the Moruya-Congo area. This population may be a result of translocation (Daly & Senior, 2003).

During this survey *E. quoyii* was sympatric with *E. heatwolei* at low altitude and *E. heatwolei* was sympatric with *E. tympanum* at high altitude. All species of *Eulamprus* within the study area utilise large fallen logs as refugia. In Tallaganda and Badja SF *E. heatwolei* and *E. tympanum* were most commonly detected on (58% of observations) or under logs (15%)

by Goldingay *et al.* (1996). Although no quantitative assessment of habitat was undertaken during the current survey casual observations indicated a high association of these species to large logs.

Range extensions - limits of distribution

The detection of *C. virgatus* by Wellington and Wells (1994) extends the known range of this species south of Morton NP (Daly, 2006) by some 100 km. They also found *E. quoyii* in the headwaters of the Tuross River, Dampier SF, which extends the range of this species south from the Buckenbowra region (this study) some 50 km. The detection of *Egernia whitii* in Long Beach NR is considered significant because the population appears to be small and restricted in distribution to the coastal dunal system. Swan *et al.* (2004) do not indicate *Tympanocryptis diemensis* as occurring in the study area. However, distribution maps of that text are based on voucher specimens and this indicates the relative paucity of collections from the region.

Two atypical forms of *L. delicata* were detected during the current study. One form detected at Wadbilliga NP (Razorback Fire trail) was relatively large being 100 mm in total length, melanistic in colouration and with a more elongate body than typical *L. delicata*. The other form found 10 km south of Bodalla was distinguished by being relatively smaller than typical *L. delicata* being only about 70 mm in total length. Both forms have restricted distributions. Voucher specimens were collected for taxonomic analysis and sent to the Australian Museum. However, to date no analysis has been conducted (R. Sadlier, pers. comm.).

Litoria fallax was detected by Daly and Senior (2003) in Batemans Bay adjacent to human settlement. The species appears to have been translocated into the area. *Pseudophryne dendyi* was found in the Narooma area. There has been debate as to the rigidity of external character morphology assigned to *P. bibronii* and *P. dendyi* (Barker & Grigg, 1977). Anstis (2002) states that hybridisation occurs in the Jervis Bay/Nowra region but external characters may not be definitive in

the *P. bibronii* complex (M. Mahony, pers. comm.). Specimens assigned to *P. dendyi* in the current study had large patches of yellow covering the top of the upper arm and from the cloaca along the hind leg and a small patch on the nasal area. The form attributed to *P. dendyi* occurred at low altitude.

Litoria verreauxii varied considerable in colouration and dorsal markings in different locations in the study area. Some individuals from high altitude had markings similar to *L. verreauxii alpina*, except the dorsum was not "warty". The genetics of this species complex is currently under revision (L. Price, pers. comm.).

Significance of area for threatened species

Two *M. balbus* tadpoles were found at Big Belimba Creek during surveys on 13 December 1998. Adult *M. balbus* were later detected at this site and Red Creek after males responded to the broadcast of call playback (Daly *et al.*, 2002). Hunter (2001) conducted targeted searches for *M. balbus* at 37 creeks in southern NSW but detected no adults. Hunter (2001) did not employ call playback during spotlighting and this may have had a bearing on his results. *Mixophyes balbus* has had a drastic population decline in southern and central NSW (Daly *et al.*, 2002, Gaia Research, 2006a,b) and may no longer persist in the region. One amphibian (*Lit. lesueurii*) affected by *Batrachochytrium* (chytrid) fungus was found in Big Belimba Creek and this disease is implicated in the decline of *M. balbus* (Daly *et al.*, 2002).

Heleioporus australiacus is rare in the region with eight records (Penman *et al.*, 2004) from Wandella and Bodalla SF. Tadpoles and breeding sites for this species were not detected during this and others surveys in the area (Lemckert *et al.*, 1998; Penman *et al.*, 2004). In contrast the author has located 14 breeding sites in the adjacent Shoalhaven region by the presence of tadpoles. Since tadpoles can take up to twelve months in the wild to complete metamorphosis (Daly, 1996) the absence of tadpoles in the study area may be

Table 6. Occurrence of reptiles by reserve/state forest/property on the south coast of New South Wales. Total animals and species (all records) are given for sites. Numeralla Mt incorporates surveys on crown land plus three sites on freehold. Freehold includes results of seven sites within a kilometre of the coast. Opportunistic records made during this survey are indicated with X and W represents additional species recorded by Wellington and Wells (1994).

Species	Common name	Badja SF	Bodalla SF	Buckenbrowa SF	Dampier SF	Long Swamp Res	Mogo SF	Monga NP	Moruya SF	Numeralla Mt	Wadbilliga NP	Wandella SF	Freehold	Total Animals
<i>Chelodina longicollis</i>	Long-necked Tortoise		X	1	W	X						W		X
<i>Varanus varius</i>	Lace Monitor	W			W									1
<i>Amphibolurus muricatus</i>	Jacky Dragon				W	X				2		W		2
<i>Physignathus lesueurii howittii</i>	Gippsland Water Dragon				W						1	W		1
<i>Tympanocryptis diemensis</i>	Mountain Dragon				2					X				2
<i>Bassiana platynota</i>	Red-throated Skink		1	1	W									2
<i>Cryptoblepharus virgatus</i>					W									
<i>Egernia cunninghami</i>	Cunningham Skink									2				2
<i>Egernia saxatilis</i>	Black Rock Skink	12		1	1					1				15
<i>Egernia whitii</i>	White's Skink					X				1				1
<i>Eulamprus heatwolei</i>	Southern Water Skink	19	7	15	39		6	5	3	38	14	W	8	154
<i>Eulamprus quoyii</i>	Eastern Water-skink			6	W									6
<i>Eulamprus tenuis</i>	Barred-sided skink		1		1		1						X	3
<i>Eulamprus tympanum</i>	Highland Water Skink	48									31			79

<i>Hemiergis decrestensis</i>		16	13	40		8	6	13	5		W	76	5
<i>Lampropholis delicata</i>	Dark-flecked Sunskink	10	15	95	X				1		W	14	172
<i>Lampropholis guichenoti</i>	Pale-flecked Sunskink	5	2	1				1	25	12	W		168
<i>Nannoscincus maccayi</i>	Maccoy's Skink	4					2			4	W		13
<i>Pseudemoia coventryi</i>									6	1			8
<i>Pseudemoia entrecasteauxii</i>	Woodland Tussock Skink	10	2							11			7
<i>Pseudemoia spenceri</i>	Spencer's Skink	2	4	6					8		W	3	23
<i>Saproscincus mustelinus</i>	Weasel Skink	X								X			25
<i>Tiliqua nigrolutea</i>	Blotched Blue-tongue												X
<i>Tiliqua scincoides</i>	Common Blue-tongue												X
<i>Morelia spilota spilota</i>	Diamond Python												X
<i>Austrelaps ramsayi</i>	Highland Copperhead	X								1			1
<i>Drysdalia rhodogaster</i>	Masters' Snake		1										1
<i>Notechis scutatus</i>	Tiger Snake	X											X
<i>Pseudochis porphyriacus</i>	Red-bellied Black Snake			W		1				X	W	1	2
<i>Pseudonaja textilis</i>	Eastern Brown Snake	X								X			X
<i>Rhinoplocephalus nigrescens</i>	Small-eyed Snake		1										2
	Total species	12	10	11	15	4	4	3	11	12	9	6	
	Number of sites	8	3	9	9	0	3	3	5	13	0	6	62

Table 7. Occurrence of amphibian by reserve/state forest/property on the south coast of New South Wales. Total animals given for systematic streamside searches, total species all records. Records made during the survey are indicated with either X = incidental observations, A = within one kilometre of reserve/forest. W = recorded by Wellington and Wells (1994).

Species	Common Name	Bodia SF	Bodalla SF	Buckenbowra SF	Dampier SF	Devon NP	Long Swamp Res	Mogo SF	Monga NP	Moruya SF	Wadbilliga NP	Wandella SF	Total Animals
<i>Litoria citropa</i>	Blue Mountains Tree Frog		X		3			X			3		6
<i>Litoria dentata</i>	Bleating Tree Frog				W							W	
<i>Litoria ewingii</i>	Ewing's Tree Frog				1	X	X	1		1	1	X	4
<i>Litoria jervisiensis</i>	Jervis Bay Tree Frog						X	A					
<i>Litoria lesueurii</i>	Lesueur's Frog	X	X		6	2				X	13	X	21
<i>Litoria nudidigitus</i>	Leaf Green Tree Frog		1		19	11			12	11	6	1	61
<i>Litoria peronii</i>	Peron's Tree Frog		X		1		X	2					3
<i>Litoria verreauxii</i>	Verreaux's Tree Frog	A	2		W		X	A			1		3
<i>Crinia signifera</i>	Common Eastern Froglet	19	2	4	13	2	X	X	X		29	21	90
<i>Heleioporus australiacus</i>	Giant Burrowing Frog						X					W	
<i>Limnodynastes dumerilii</i>	Pobblebonk	X			W						1		1
<i>Limnodynastes peronii</i>	Striped Marsh Frog		1			1	X	X	X	2	3	2	9
<i>Limnodynastes tasmaniensis</i>	Spotted Grass Frog	A											
<i>Mixophyes balbus</i>	Southern Barred Frog				3								3
<i>Paracrinia haswelli</i>	Haswell's Frog						X						
<i>Pseudophryne bibionii</i>	Bibron's Toadlet	1		4	1			X		2	1		9
<i>Pseudophryne dendyi</i>	Southern Toadlet		X										
<i>Uperoleia tyleri</i>	Tyler's Toadlet						X						
Total animals		20	6	8	47	16		3	12	16	58	23	
Total species		6	8	2	11	5	8	6	3	5	9	7	

a reflection of the species patchy distribution, low abundance or a difference to the northern form in breeding habitat. There is a gap in distribution records from Narooma (Wandella and Bodalla SF) to Morton NP (Daly, 1996; Penman *et al.*, 2004). There are also differences in adult morphology, habitat (pers. obs.) and the genetic composition (Morgan *et al.*, 2007) of the northern and southern forms.

No *Lit. aurea* or *Lit. littlejohni* were detected during this and other recent surveys. The decline in *Lit. aurea* has been associated with the amphibian chytrid fungus (DEC, 2005). The absence of *Lit. littlejohni* probably reflects the species patchy distribution and low density in this region as tadpoles can take between 3-17 months to complete metamorphosis (unpubl. data).

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Appendix A. Locations of reptile survey sites.

Site	Location	Map	Easting	Northing	Altitude	Reserve/State Forest
001AR	Big Rock Rd, Bodalla SF	Narooma	769500	6009550	150	Bodalla SF
001AM	Big Rock Rd, Bodalla SF	Cadgee	769400	5995000	70	Bodalla SF
001AG	Fire trail 16/5 Bodalla SF	Cadgee	230550	5909900	35	Bodalla SF
001BR	Western Boundary Rd	Bodalla	230800	5994600	160	Moruya SF
001BM	Little Bumbo FT	Nerrigundah	770300	6009900	70	Moruya SF
001BG	Little Bumbo FT	Nerrigundah	769400	5994800	55	Moruya SF
003AR	Bumberry Ck FT	Yowrie	727800	5979500	1000	Wadbilliga NP
003AM	Burkes Rd	Yowrie	728500	5980800	940	Wadbilliga NP
003AG	Bumberry Ck FT	Yowrie	729000	5980800	890	Wadbilliga NP
003BR	Woila Ck FT	Badja	732400	6002800	1110	Badja SF
003BM	Woila Ck FT	Badja	731500	6003000	1080	Badja SF
003BG	North from Falcon Rd	Badja	732200	6000000	900	Badja SF
003CR	500m from Burked Rd	Belowra	728000	5993400	1010	Badja SF
003CM	Compartment 9 Rd	Belowra	728800	5993200	960	Badja SF
003CG	Off Burkes Rd	Belowra	727300	5993600	990	Wadbilliga NP
005AR	Razorback FT	Yowrie	730400	5974200	1140	Wadbilliga NP
005AM	Razorback FT	Yowrie	731400	5973800	1210	Wadbilliga NP
005AG	Razorback FT	Yowrie	729500	5972300	1070	Wadbilliga NP
005BR	Razorback FT	Yowrie	735200	5972100	1190	Wadbilliga NP
005BM	Razorback FT	Puen Buen	735600	5971300	1160	Wadbilliga NP
005BG	Razorback FT	Yowrie	736000	5971800	1000	Wadbilliga NP
005CR	Wadbilliga FT	Yowrie	730500	5980600	950	Wadbilliga NP
005CM	Wadbilliga FT	Yowrie	731300	5981300	820	Wadbilliga NP
005CG	Wadbilliga FT	Yowrie	732300	5981900	570	Wadbilliga NP
007AR	Corn trail, Clyde Mt	Monga	767100	6060500	790	Buckenbowra SF
007AM	Corn trail, Clyde Mt	Monga	767450	6061200	780	Buckenbowra SF
007AG	Off Kings Highway	Monga	766400	6061700	720	Buckenbowra SF
007BR	Bolaro Mt Rd	Nelligen	231900	6048600	630	Buckenbowra SF
007BM	Bolaro Mt Rd	Nelligen	231200	6049500	540	Buckenbowra SF
007BG	Old Belaro Rd	Nelligen	230300	6052100	310	Buckenbowra SF
007CR	Misty Mt Rd	Monga	770300	6058650	480	Buckenbowra SF
007CM	Misty Mt Rd	Monga	770000	6056700	600	Buckenbowra SF
007CG	Misty Mt Rd	Monga	770100	6057500	620	Buckenbowra SF
009BR	Eink Rd/814/1	Monga	763100	6061000	720	Monga NP
009BM	Eink Rd	Monga	752900	6059700	750	Monga NP
009BG	Via Reidsdale Rd	Monga	760600	6061300	720	Monga NP
019R	Saltwater Rd	Nelligen	240250	6040200	50	Mogo SF
019M	Off Runnyford Rd	Nelligen	239900	6043600	25	Mogo SF
019G		Nelligen	239300	6042800	5	Mogo SF
029R	Off Tinpot Rd	Wandella	757000	5982300	395	Dampier SF
029M	Off Tinpot Rd	Wandella	759300	5983250	210	Dampier SF
029G	Red Ck Rd	Wandella	758550	5983350	165	Dampier SF
030R	Off Belimba Ridge Rd	Cadgee	754200	5998200	440	Dampier SF
030M	Bryces Rd	Cadgee	753150	5997100	340	Dampier SF
030G	Bryces Rd	Nerrigundah	755450	5998800	280	Dampier SF
031R	Hell Hole Rd	Cadgee	752200	5993900	270	Dampier SF
031M	Hell Hole Rd	Cadgee	753050	5994900	200	Dampier SF
031G	Hell Hole Rd	Cadgee	752200	5995100	130	Dampier SF
032R	Tuross River Rd	Belowra	725900	5988800	930	Badja SF
032R	Tuross River Rd	Belowra	725900	5988800	930	Badja SF
032M	Tuross River Rd	Belowra	725000	5990950	1050	Badja SF
032G	Tuross River Rd	Belowra	725100	5990050	920	Badja SF
033R	W. Reid property	Numeralla	717550	5987150	1020	Freehold
033M	W. Reid property	Numeralla	718000	5986100	1005	Freehold
033G	W. Reid property	Numeralla	715400	5987350	810	Freehold
034R	Kydra East F/T	Numeralla	715300	5989550	1100	Crown land
Ridge Rd G	Malua Bay	Mogo	248507	6035936	20	Freehold
Ridge Rd R	Malua Bay	Mogo	248688	6035942	40	Freehold
Glasshouse G	Narooma	Narooma	241800	5986250	15	Freehold
Broulee M		Mogo	244400	6030000	5	Freehold
Kiangra Lake	Narooma	Narooma	241800	5991300	20	Freehold
Dalmeny G1	Narooma	Narooma	240300	5993100	10	Freehold
Dalmeny R1	Narooma	Narooma	240576	5992710	40	Freehold

Appendix B. Locations of amphibian streamside search sites.

Site	Location	Map	Easting	Northing	Altitude	Reserve/State Forest
001AG	Bodalla SF	Cadgee	769400	5994800	35	Bodalla SF
001BG		Nerrigundah	769400	5994800	55	Moruya SF
003AG		Yowrie	728500	5980200	890	Wadbilliga NP
003BG	North from Falcon Rd	Badja	732200	6000000	900	Badja SF
003CG		Belowra	727300	5993600	990	Wadbilliga NP
005AG		Yowrie	729500	5972300	1070	Wadbilliga NP
005BG	Corn Trail/Clyde Mt	Yowrie	736000	5971800	1000	Wadbilliga NP
005CG		Yowrie	732300	5981900	570	Wadbilliga NP
007AG		Monga	766400	6061700	720	Buckenbowra SF
007BG		Nelligen	230300	6052100	310	Buckenbowra SF
007CG		Monga	770100	6057500	620	Buckenbowra SF
009BG		Monga	760600	6061300	720	Buckenbowra SF
019G	Red Ck Rd	Nelligen	239300	6042800	5	Mogo SF
029G		Wandella	758550	5983350	165	Dampier SF
030G		Nerrigundah	755450	5998800	280	Dampier SF
031G	Hell Hole Rd	Cadgee	752200	5995100	130	Dampier SF
032G	Tuross River Rd	Belowra	725100	5990050	920	Badja SF
033G	W. Reid property	Numeralla	715400	5987350	810	Freehold
034G	Glen Fergus SF	Numeralla	705700	5994450	860	State Forest
17a	Big Belimba Creek a	Nerrigundah	753600	6004500	230	Dampier SF
17b	Big Belimba Creek b	Nerrigundah	753700	6004100	230	Dampier SF
17c	Big Belimba Creek c	Nerrigundah	753600	6004600	230	Dampier SF
17d	Big Belimba Creek d	Nerrigundah	754000	6004700	230	Dampier SF
20	Fern Creek	Wandella	754250	5983300	90	Wandella SF
21	Welsh's Rd Creek	Wandella	754650	5980750	110	Wandella SF
22a	Red Creek a	Cadgee	757500	5986450	60	Dampier SF
22b	Red Creek b	Cadgee	757450	5986950	60	Dampier SF
23a	Bumbo Ck a	Nerrigundah	762500	6006350	130	Dampier SF
23b	Bumbo Ck b	Nerrigundah	762800	6006300	130	Dampier SF
24a	Pinkwood Creek	Nerrigundah	759400	6011700	630	Dampier SF
24b	Pinkwood Creek	Nerrigundah	759600	6011800	630	Dampier SF
25	Trapyard Creek	Yowrie	745000	5972600	260	Wadbilliga NP
26a	New England Creek a	Yowrie	744200	5971200	250	Wadbilliga NP
26b	New England Creek b	Yowrie	743850	5971200	280	Wadbilliga NP
27	New England Creek c	Puen Buen	743250	5970700	280	Wadbilliga NP
34a	Buckyjumba Ck a	Badja	747800	6004800	230	Dampier SF
34b	Buckyjumba Ck b	Badja	747200	6004600	230	Dampier SF
34c	Buckyjumba Ck c	Badja	747200	6004100	230	Dampier SF
36	Dwyers Ck	Moruya	233800	6014400	60	Moruya SF
37a	Coila Ck a	Bodalla	233900	6011250	30	Moruya SF
37b	Coila Ck b	Bodalla	234100	6011200	30	Moruya SF
38a	Coila Ck	Bodalla	234100	6010300	40	Moruya SF
38b	Coila Ck	Bodalla	233900	6010250	40	Moruya SF
39a	McCarthy's Ck a	Monga	760700	6059300	710	Monga SF
39b	McCarthy's Ck b	Monga	760500	6059300	710	Monga SF
40a	Mongarlowe River*	Monga	764400	6058200	700	Monga SF
40b	Mongarlowe River*	Monga	764400	6058100	700	Monga SF
41	Tributary of Mongarlowe R	Monga	764800	6061350	680	Monga SF
42	Merricumbene Ck	Araluen	763100	6042500	100	Freehold
43a	Kenney's Ck	Burrumbela	764900	6039600	70	Duea NP
43b	Kenney's Ck	Araluen	765300	6040000	80	Duea NP

HERPETOLOGICAL NOTES

AN OBSERVATION OF PROBABLE PREDATION OF A NORTHERN LEAF-TAILED GECKO BY A GREEN CATBIRD

Francis Lemckert*, Georgina Lemckert, Campbell Lemckert and Frances Lemckert

* Author and address for correspondence: Forest Biodiversity, Department of Primary Industries, PO Box 100, Beecroft, NSW 2119.

On 9 October 2005, we observed an instance of predation of a reptile whilst on a walking track within 500 m of O'Reillys Guest House on the Lamington Plateau of the NSW/Queensland Border. At around 12:30 pm we observed a largish bird moving on the ground. We identified it as a Green Catbird (*Ailuroedus crassirostris*) that was in the process of ripping apart a Northern Leaf-tailed Gecko (*Saltuarius swaini*). The catbird was thrashing the gecko from side to side and pulling at its abdomen, slowly breaking sections off the body and consuming them. The gecko was approximately 7-8 cm snout-vent length and it was in an area of subtropical rainforest. How the catbird located a nocturnal gecko is unclear, but most likely found it sheltering amongst the root system of a tree.

Green Catbirds are noted to eat nestling birds to feed their young (Higgins *et al.*, 2006) and

October falls within their main breeding season. Hence it seems likely that this was an adult bird supplementing its normal diet of fruits with meat. However, the consumption of reptile prey must be a relatively rare event as it was never observed in an eight year study of catbirds in south-east Queensland (Innes & McEvoy, 1992).

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OBJECTS INADVERTENTLY SWALLOWED BY CAPTIVE AUSTRALIAN FROGS

Michael J. Tyler

Environmental Biology, School of Earth and Environmental Sciences,
University of Adelaide, SA 5005.

The process of ingestion of food items by frogs varies with the sizes of the animal and the food item. Whereas small species exclusively use their tongue to capture and ingest small insects and other prey, large species commonly lunge forwards to secure the item with their tongue and jaws. They then may use their hands to push the prey into the buccal cavity. Both of these processes by large frogs involve a high risk of non-target matter being ingested with or instead of the intended prey item.

Here I report two instances of frogs that had ingested large items of inanimate material, and comment on the material that is undesirable for use on the floor of vivaria.

Case 1

An adult White-lipped Tree Frog (*Litoria infrafrenata*), with a head plus body length of approximately 100 mm, was referred to a veterinarian because it was said to be consti-

pated. Palpation revealed a hard mass in the stomach instead of the rectum, and the mass was expressed by the application of gentle pressure. The object was a small, smooth grey stone. The stone measured 23.7 x 17.3 mm, had a maximum thickness of 8.9 mm and weighed 5.25 grams (Fig. 1).

Case 2

An adult White's Tree Frog (Green Tree Frog) *Litoria caerulea* of 70 mm, weighing 29 grams was found to have swallowed an ornamental, circular glass disc with a diameter of 20.5 mm and a maximum depth of 7.5 mm (Fig. 1). It weighed 4.5 grams. The object was also expressed by gentle palpation and compression.

These observations indicate that the size of small unsecured objects on the floor of vivaria should not have any dimension smaller than the mouth gape of the frogs inhabiting it.

Figure 1. Stone removed from the stomach of *Litoria infrafrenata* and glass disc removed from the stomach of *Litoria caerulea*. Scale bar = 1 cm.



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